

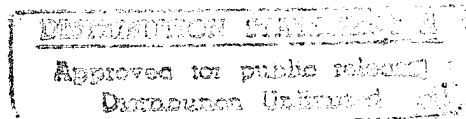
**United States Air Force
611th Air Support Group/
Civil Engineering Squadron**

Elmendorf AFB, Alaska

Final

Risk Assessment

**Point Barrow Radar Installation,
Alaska**



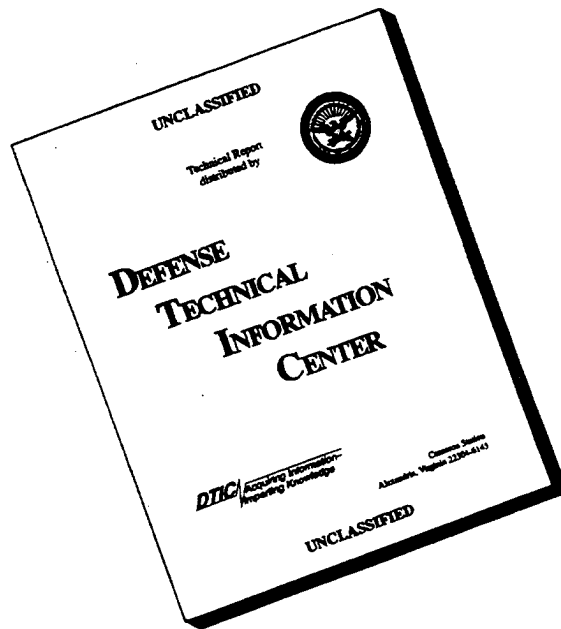
19960808 091

Prepared by:

ICF Technology Incorporated

19 FEBRUARY 1996

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

THIS PAGE INTENTIONALLY LEFT BLANK

PREFACE

This report presents the findings of Risk Assessments at sites located at the Point Barrow radar installation in northern Alaska. The sites were characterized based on sampling and analyses conducted during Remedial Investigation activities performed during August and September 1993. This report was prepared by ICF Technology Incorporated.

This report was prepared between January 1995 and February 1996. Mr. Samer Karimi of the Air Force Center for Environmental Excellence was the Alaska Restoration Team Chief for this task. Dr. Jerome Madden and Mr. Richard Borsetti of the 611th CES/CEVR were the Remedial Project Managers for the project.

Approved:

Thomas McKinney
Program Director
ICF Technology Incorporated

THIS PAGE INTENTIONALLY LEFT BLANK

NOTICE

This report has been prepared for the United States Air Force (Air Force) by ICF Technology Incorporated for the purpose of aiding in the implementation of final remedial actions under the Air Force Installation Restoration Program (IRP). As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance does not mean that the United States Air Force adopts the conclusions, recommendations or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

Government agencies and their contractors registered with the Defense Technical Information Center (DTIC) should direct requests for copies of this report to: DTIC, Cameron Station, Alexandria, Virginia 22304-6145.

Non-Government agencies may purchase copies of this document from: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

1.0	INTRODUCTION	1-1
1.1	ORGANIZATION OF REPORT	1-1
1.2	RISK ASSESSMENT GUIDANCE DOCUMENTS	1-6
1.3	INSTALLATION DESCRIPTION AND ENVIRONMENTAL SETTING	1-6
1.4	APPROACH TO HUMAN HEALTH RISK ASSESSMENT	1-13
1.5	APPROACH TO ECOLOGICAL RISK ASSESSMENT	1-13
2.0	BASELINE HUMAN HEALTH RISK ASSESSMENT	2-1
2.1	IDENTIFICATION OF CHEMICALS OF CONCERN	2-1
2.1.1	Sampling Strategy and Evaluation of Analytical Data	2-2
2.1.2	Risk-Based Screening Levels	2-3
2.1.2.1	Formulae for Calculating RBSLs	2-3
2.1.3	Screening of Chemicals by Comparing Maximum Detected Concentrations of Essential Human Nutrients	2-5
2.1.4	Concentrations of Organic and Inorganic Constituents in Background Samples	2-5
2.1.5	Selection of Chemicals of Concern	2-9
2.1.5.1	Diesel Fuel Spill (SS01)	2-17
2.1.5.2	Garage (SS02)	2-17
2.1.5.3	Air Terminal Area (SS03)	2-23
2.1.5.4	Summary of Chemicals of Concern	2-23
2.2	EXPOSURE ASSESSMENT	2-23
2.2.1	Pathway Analysis	2-23
2.2.1.1	Soil and Sediment Ingestion	2-27
2.2.1.2	Inhalation	2-27
2.2.1.3	Water Ingestion	2-27
2.2.1.4	Ground Water	2-32
2.2.2	Migration and Fate of Chemicals of Concern	2-32
2.2.3	Estimation of Chemical Intake	2-33
2.2.3.1	Exposure Point Concentration	2-34
2.2.3.2	Exposure Frequency	2-34
2.2.3.3	Exposure Duration	2-35
2.2.3.4	Averaging Time	2-35
2.2.3.5	Ingestion of Locally Produced Meat, Fish, and Vegetation	2-35
2.2.3.6	Soil Ingestion Rate	2-36
2.2.3.7	Drinking Water Ingestion Rate	2-36
2.2.3.8	Dermal Contact with Soil Rate	2-36
2.2.3.9	Inhalation Rate	2-36
2.2.3.10	Body Weight	2-36
2.2.4	Quantifying Exposure	2-36

TABLE OF CONTENTS (CONTINUED)

2.3	TOXICITY ASSESSMENT	2-38
2.3.1	Toxicity Assessment for Noncarcinogenic Effects	2-38
2.3.1.1	Concept of Threshold	2-40
2.3.2	Toxicity Assessment For Carcinogenic Effects	2-40
2.3.2.1	Concept of Nonthreshold Effects	2-40
2.3.2.2	Assigning a Weight-of-Evidence	2-40
2.3.2.3	Generating a Slope Factor	2-42
2.3.2.4	Identifying the Appropriate Data Set	2-42
2.3.2.5	Extrapolating to Lower Doses	2-42
2.3.2.6	Summary of Dose-Response Parameters	2-43
2.3.3	Summaries of the Toxicity of the Chemicals of Concern	2-43
2.4	RISK CHARACTERIZATION	2-43
2.4.1	Quantifying Risks	2-44
2.4.1.1	Risks from Individual Substances - Carcinogenic Effects	2-44
2.4.1.2	Noncancer Hazards from Individual Substances - Noncancerous Effects	2-44
2.4.1.3	Aggregate Risks for Multiple Substances	2-45
2.4.2	Site-Specific Risk Characterization	2-47
2.4.2.1	Diesel Fuel Spill (SS01)	2-50
2.4.2.2	Garage (SS02)	2-51
2.4.2.3	Air Terminal Area (SS03)	2-51
2.5	RISK CHARACTERIZATION UNCERTAINTY	2-52
2.6	RISK ASSESSMENT SUMMARY AND CONCLUSIONS	2-54
3.0	ECOLOGICAL RISK ASSESSMENT	3-1
3.1	SELECTION OF SITE CONTAMINANTS	3-2
3.1.1	Surface Water	3-7
3.1.1.1	Organic Compounds	3-7
3.1.1.2	Metals	3-9
3.1.2	Soils and Sediments	3-11
3.1.2.1	Petroleum Hydrocarbons	3-11
3.1.2.2	Benzene, Toluene, Ethylbenzene, and Xylenes	3-12
3.1.2.3	Halogenated Volatile Organic and Volatile Organic Compounds	3-12
3.1.2.4	Semivolatile Organic Compounds	3-13
3.1.2.5	Polychlorinated Biphenyls	3-13
3.1.2.6	Metals	3-14
3.2	ECOLOGICAL EXPOSURE ASSESSMENT	3-16
3.2.1	Species of the Arctic Coastal Plain	3-17
3.2.1.1	Plants	3-17
3.2.1.2	Aquatic Organisms	3-18
3.2.1.3	Birds	3-18
3.2.1.4	Mammals	3-18

TABLE OF CONTENTS (CONTINUED)

3.2.1.5	Threatened and Endangered Species	3-19
3.2.2	Representative Species	3-19
3.2.2.1	Representative Plants	3-21
3.2.2.2	Representative Aquatic Invertebrates and Fish	3-21
3.2.2.3	Representative Birds	3-21
3.2.2.4	Representative Mammals	3-21
3.2.2.5	Threatened and Endangered Species	3-22
3.2.3	Exposure Pathways	3-22
3.2.4	Habitat Suitability for Representative Species	3-25
3.2.5	Exposure Assessment for Representative Species of Plants	3-26
3.2.6	Exposure Assessment for Representative Aquatic Organisms	3-26
3.2.7	Exposure Estimates for Representative Bird and Mammal Species	3-26
3.2.7.1	Potential Bioaccumulation of COCs in Representative Species	3-27
3.2.7.2	Estimation of Percent Ingested Onsite	3-28
3.2.7.3	Exposure Assessment for Representative Species of Birds	3-30
3.2.7.4	Exposure Assessment for Representative Species of Mammals	3-35
3.3	ECOLOGICAL TOXICITY ASSESSMENT	3-38
3.3.1	Petroleum Hydrocarbons	3-38
3.3.1.1	Plants	3-41
3.3.1.2	Aquatic Organisms	3-41
3.3.1.3	Birds	3-41
3.3.1.4	Mammals	3-41
3.3.2	Toluene	3-42
3.3.2.1	Plants	3-42
3.3.2.2	Aquatic Organisms	3-42
3.3.2.3	Birds	3-42
3.3.2.4	Mammals	3-42
3.3.3	Xylene	3-42
3.3.3.1	Plants	3-42
3.3.3.2	Aquatic Organisms	3-42
3.3.3.3	Birds	3-42
3.3.3.4	Mammals	3-43
3.3.4	Polychlorinated Biphenyls	3-43
3.3.4.1	Plants	3-43
3.3.4.2	Aquatic Organisms	3-43
3.3.4.3	Birds	3-43
3.3.4.4	Mammals	3-43
3.3.5	Iron	3-44
3.3.5.1	Plants	3-44

TABLE OF CONTENTS (CONTINUED)

3.3.5.2	Aquatic Organisms	3-44
3.3.5.3	Birds	3-44
3.3.5.4	Mammals	3-44
3.3.6	Lead	3-44
3.3.6.1	Plants	3-44
3.3.6.2	Aquatic Organisms	3-45
3.3.6.3	Birds	3-45
3.3.6.4	Mammals	3-45
3.3.7	Zinc	3-45
3.3.7.1	Plants	3-45
3.3.7.2	Aquatic Organisms	3-45
3.3.7.3	Birds	3-45
3.3.7.4	Mammals	3-46
3.3.8	Characterization of Effects	3-46
3.3.8.1	Toxicity Reference Values	3-46
3.4	RISK CHARACTERIZATION FOR ECOLOGICAL RECEPTORS	3-54
3.4.1	Potential Risks to Representative Species of Plants	3-54
3.4.2	Potential Risks to Representative Species of Aquatic Organisms ..	3-56
3.4.3	Potential Risks to Representative Species of Birds	3-57
3.4.4	Potential Risks to Representative Species of Mammals	3-61
3.4.5	Potential Future Risks	3-61
3.5	ECOLOGICAL RISK ASSESSMENT UNCERTAINTY ANALYSIS	3-62
3.5.1	Environmental Sampling and Analysis	3-62
3.5.2	Selection of Chemicals for Evaluation	3-63
3.5.3	Selection of Representative Species	3-64
3.5.4	Exposure Assessment	3-64
3.5.5	Toxicological Data	3-65
3.6	SUMMARY OF ECOLOGICAL RISK	3-66
3.6.1	Potential Risks to Representative Plants	3-66
3.6.2	Potential Risks to Representative Aquatic Species	3-66
3.6.3	Potential Risks to Representative Species of Birds and Mammals .	3-67
4.0	REFERENCES	4-1

TABLE OF CONTENTS (CONTINUED)

APPENDICES

- A RISK CHARACTERIZATION SPREADSHEETS
- B TOXICITY PROFILES
- C BIOCONCENTRATION FACTOR CALCULATIONS
- D CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS
- E ESTIMATED EXPOSURE EQUATIONS
- F SCALING FACTOR CALCULATIONS
- G RI ANALYTICAL DATA

LIST OF TABLES

1-1.	SITES EVALUATED AT THE POINT BARROW DEW LINE INSTALLATION	1-5
2-1.	IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT POINT BARROW	2-10
2-2.	CHEMICALS WITHOUT RBSLS AND ARARS OBSERVED IN THE SOIL, SEDIMENT, OR SURFACE WATER AT THE POINT BARROW INSTALLATION . . .	2-15
2-3.	SUMMARY OF THE CHEMICALS OF CONCERN AT POINT BARROW	2-18
2-4.	EXPOSURE PATHWAY ANALYSIS FOR POINT BARROW HUMAN HEALTH RISK ASSESSMENT	2-31
2-5.	EXPOSURE ASSUMPTIONS FOR ESTIMATING CHEMICAL INTAKE	2-34
2-6.	EQUATIONS USED FOR ESTIMATING POTENTIAL DOSE	2-37
2-7.	TOXICITY CRITERIA FOR NONCANCER EFFECTS OF THE CHEMICALS OF CONCERN FOR POINT BARROW	2-39
2-8.	TOXICITY VALUES FOR THE CARCINOGENICITY OF THE CHEMICALS OF CONCERN AT POINT BARROW	2-41
2-9.	EPA WEIGHT-OF-EVIDENCE CLASSIFICATION SYSTEM FOR CARCINOGENICITY	2-42
2-10.	SUMMARY OF NONCANCER HAZARD AND EXCESS LIFETIME CANCER RISK FOR POINT BARROW	2-49
2-11.	SUMMARY OF SITES WITH CONTAMINATION THAT EXCEEDS REGULATORY BENCHMARKS	2-55
3-1.	SUMMARY OF CHEMICALS OF CONCERN: SURFACE WATER	3-3
3-2.	SUMMARY OF CHEMICALS OF CONCERN: SOILS AND SEDIMENTS	3-5
3-3.	REPRESENTATIVE AND SENSITIVE SPECIES AT THE ARCTIC DEW LINE INSTALLATION SITES	3-20
3-4.	BIOCONCENTRATION FACTORS FOR SELECTED ORGANIC COMPOUNDS IN WATER	3-29
3-5.	LIFE HISTORY INFORMATION FOR THE LAPLAND LONGSPUR, <i>Calcarius</i> <i>lapponicus</i>	3-32
3-6.	LIFE HISTORY INFORMATION FOR THE BRANT, <i>Branta bernicla</i>	3-32
3-7.	LIFE HISTORY INFORMATION FOR THE GLAUCOUS GULL, <i>Larus hyperboreus</i> .	3-33
3-8.	LIFE HISTORY INFORMATION FOR THE PECTORAL SANDPIPER, <i>Calidris</i> <i>melanotos</i>	3-33
3-9.	LIFE HISTORY INFORMATION FOR THE SPECTACLED EIDER, <i>Somateria</i> <i>fischeri</i>	3-34
3-10.	SOIL INGESTION ESTIMATES FOR REPRESENTATIVE AND SENSITIVE BIRD SPECIES	3-36
3-11.	LIFE HISTORY INFORMATION FOR THE BROWN LEMMING, <i>Lemmus</i> <i>trimucronatus</i>	3-36
3-12.	LIFE HISTORY INFORMATION FOR THE ARCTIC FOX, <i>Alopex lagopus</i>	3-37
3-13.	LIFE HISTORY INFORMATION FOR THE BARREN-GROUND CARIBOU, <i>Rangifer</i> <i>tarandus</i>	3-37

LIST OF TABLES (CONTINUED)

3-14.	SOIL INGESTION ESTIMATES FOR REPRESENTATIVE MAMMAL SPECIES	3-38
3-15.	CHEMICAL CLASSES OF GRPH AND DRPH	3-40
3-16.	TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF AQUATIC ORGANISMS AT THE POINT BARROW INSTALLATION	3-47
3-17.	TOXICITY REFERENCE VALUES FOR REPRESENTATIVE AND SENSITIVE SPECIES OF BIRDS AT THE POINT BARROW INSTALLATION	3-48
3-18.	TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF MAMMALS AT THE POINT BARROW INSTALLATION	3-51
3-19.	COMPARISON OF COC CONCENTRATIONS TO TOXICITY INFORMATION FOR PLANTS AT THE POINT BARROW INSTALLATION	3-55
3-20.	HAZARD QUOTIENTS FOR REPRESENTATIVE SPECIES OF AQUATIC ORGANISMS AT THE POINT BARROW INSTALLATION	3-56
3-21.	HAZARD QUOTIENTS FOR REPRESENTATIVE BIRDS AND MAMMALS AT THE POINT BARROW INSTALLATION	3-58
3-22.	RELATIVE TOXICITY RANKINGS FOR COMPARISON OF MAMMALIAN AND AVIAN TOXICITY	3-61

LIST OF FIGURES

1-1.	GENERAL LOCATION MAP	1-3
1-2.	AREA LOCATION MAP	1-7
1-3.	INSTALLATION SITE PLAN	1-9
2-1.	BACKGROUND (BKGD) SAMPLE LOCATIONS AND ORGANIC ANALYTICAL RESULTS	2-7
2-2.	DIESEL FUEL SPILL (SS01) SAMPLE LOCATIONS AND ANALYTICAL RESULTS .	2-19
2-3.	GARAGE (SS02) SAMPLE LOCATIONS AND ANALYTICAL RESULTS	2-21
2-4.	AIR TERMINAL AREA (SS03) SAMPLE LOCATIONS AND ANALYTICAL RESULTS	2-25
2-5.	HUMAN HEALTH RISK ASSESSMENT POTENTIAL EXPOSURE PATHWAYS	2-29
3-1.	ECOLOGICAL RISK ASSESSMENT POTENTIAL EXPOSURE PATHWAYS	3-23

LIST OF ACRONYMS AND ABBREVIATIONS

ADD	Average Daily Dose
Air Force	United States Air Force
API	The American Petroleum Institute
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factors
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CDI	Chronic Daily Intake
COC	Chemical of Concern
DEW	Distant Early Warning
DRPH	Diesel Range Petroleum Hydrocarbons
ECAO	Environmental Criteria and Assessment Office of EPA
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
GRPH	Gasoline Residual Petroleum Hydrocarbons
ha	Hectare
HEAST	Health Effects Assessment Summary Tables
HQ	Hazard Quotient
HVOCs	Halogenated Volatile Organic Compounds
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IS	Onsite Dietary Intake
LADD	Lifetime Average Daily Dose

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

LOAEL	Lowest-Observed Adverse Effect Level
LOEL	Lowest Observed Effect Level
MCL	Maximum Contaminant Level
MDEP	Massachusetts Department of Environmental Protection
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
NSB	North Slope Borough
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
ppm	Parts Per Million
RBSLs	Risk-Based Screening Levels
RfD	Reference Dose
RIIs	Remedial Investigations
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
RRPH	Residual Range Petroleum Hydrocarbons
SF	Slope Factor
SVOCs	Semi-Volatile Organic Compounds
TPH	Total Petroleum Hydrocarbon
TRVs	Toxicity Reference Values
VOCs	Volatile Organic Compounds
UCL	Upper Confidence Limit
UF	Uncertainty Factors

1.0 INTRODUCTION

This document contains the baseline human health risk assessment and the ecological risk assessment (ERA) for the Point Barrow Distant Early Warning (DEW) Line radar installation. Three sites at the Point Barrow radar installation underwent remedial investigations (RIs) during the summer of 1993. The presence of chemicals in the soil, sediments, and surface water at the installation was evaluated and reported in the Point Barrow Remedial Investigation/Feasibility Study (RI/FS) (U.S. Air Force 1996). The analytical data reported in the RI/FS form the basis for the human health and ecological risk assessments. The primary chemicals of concern (COCs) at the three sites are diesel and gasoline from past spills and/or leaks. The general location of the Point Barrow radar installation is shown in Figure 1-1. The three sites investigated and the types of samples collected at each site are presented in Table 1-1.

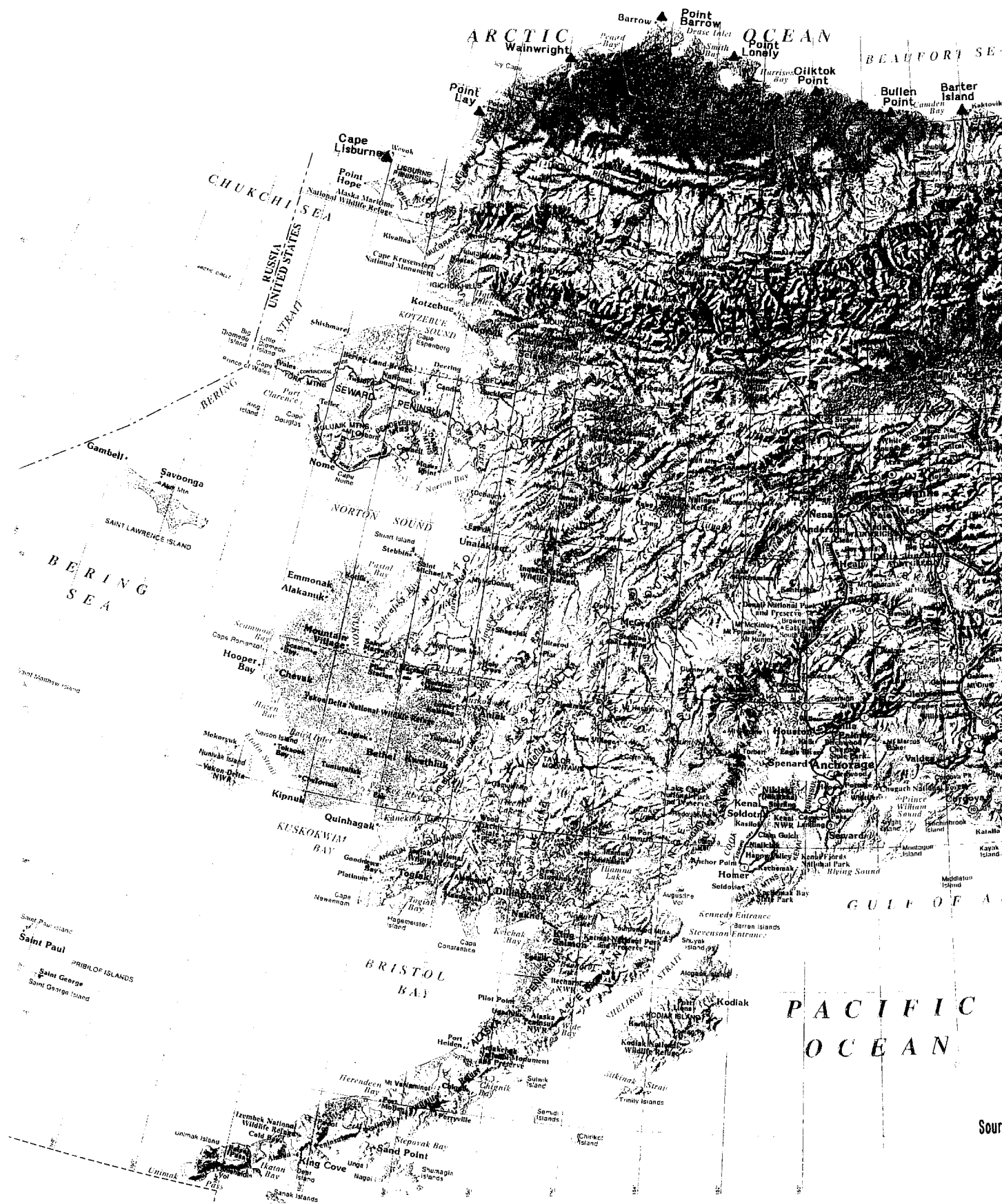
The purpose of the risk assessment is to evaluate the human health and ecological risks that may be associated with chemicals released to the environment at the three sites investigated during the RI. The risk assessment characterizes the probability that measured concentrations of hazardous chemical substances will cause adverse effects in humans or the environment in the absence of remediation. The risk assessment will be used to determine if remediation (site cleanup) is necessary and, if so, to rank sites for remedial action.

1.1 ORGANIZATION OF REPORT

Section 1.0 contains introductory information regarding the installation location and conditions, and a summary outline of the approach to the human health and ecological risk assessments. Section 2.0 is the Baseline Human Health Risk Assessment. Section 3.0 is the Ecological Risk Assessment, and references are presented in Section 4.0. Section 2.0, Baseline Human Health Risk Assessment, is composed of:

- **Selection of Site Contaminants.** Presents the COCs for human health and describes how they were selected for this risk assessment.
- **Exposure Assessment.** Identifies the pathways by which potential human exposures could occur, and estimates the magnitude, frequency, and duration of those exposures.
- **Toxicity Assessment.** Summarizes the toxicity of the selected COCs and the relationship between magnitude of exposure and the development of adverse health effects.
- **Risk Characterization.** Integrates the toxicity and exposure assessments to estimate the potential risks to human health from exposure to chemicals in environmental media.

THIS PAGE INTENTIONALLY LEFT BLANK





LEGEND

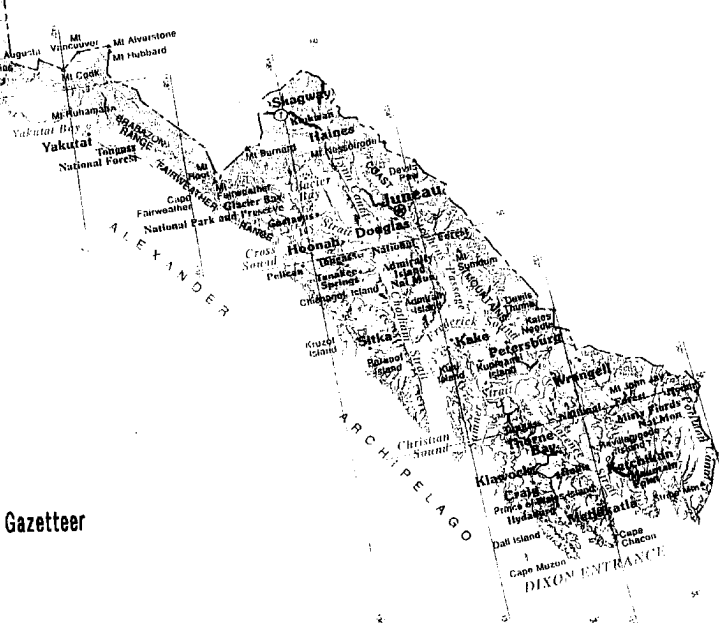
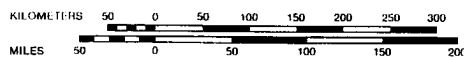
▲ RADAR SITE

ALASKA REMOTE RADAR INSTALLATION

USAF 611th CES

FIGURE NO. 1-1

GENERAL
LOCATION
MAP



Source: Alaska Atlas & Gazetteer

TABLE 1-1. SITES EVALUATED AT THE POINT BARROW DEW LINE INSTALLATION

SITE NAME	SITE ID NUMBER	SOIL	SEDIMENTS	SURFACE WATER
Diesel Fuel Spill	SS01	X	X	X
Garage	SS02	X	X	NA
Air Terminal Area	SS03	X	X	X

X Chemical analyses were performed on these media.
 NA No chemical analysis was performed.

- **Risk Characterization Uncertainty.** Describes the potential shortcomings in the data and the methods used to develop the risk assessment, and the uncertainties in the interpretation of the data and the risk characterization results.
- **Risk Assessment Summary and Conclusions.** Presents a summary of, and conclusions regarding, the potential human health risks associated with exposure to contaminated media at the three sites at the Point Barrow radar installation.

Section 3.0, the Ecological Risk Assessment (ERA), is composed of:

- **Selection of Site Contaminants.** Presents the COCs for ecological receptors and describes how they were selected for the ERA.
- **Ecological Exposure Assessment.** Identifies the potential receptors and representative species, habitat suitability, and exposure pathways.
- **Ecological Toxicity Assessment.** Describes the potential effects of site contaminants on the representative species.
- **Risk Characterization for Ecological Receptors.** Evaluates the likelihood of adverse effects on ecological receptors.
- **Ecological Uncertainty Analysis.** Describes the potential shortcomings in the data and methods used to develop the ERA, and the uncertainties in the interpretation of the data and the ecological risk characterization results.
- **Summary of Ecological Risks.** Presents a summary of ecological risks associated with contaminated media at the three sites at the installation.

Appendix A contains the human health risk assessment spreadsheets used to estimate chemical intake, noncancer hazard, and excess lifetime cancer risk. Appendix B consists of toxicology

profiles. The exposure equations and calculations for ecological receptors are presented in Appendices C through F. Appendix G contains a summary of RI sampling and analyses and the RI analytical data for all sites from which the COCs were selected and upon which the human health and ecological risk assessments are based.

1.2 RISK ASSESSMENT GUIDANCE DOCUMENTS

The following guidance documents were used to develop the human health and ecological risk assessments:

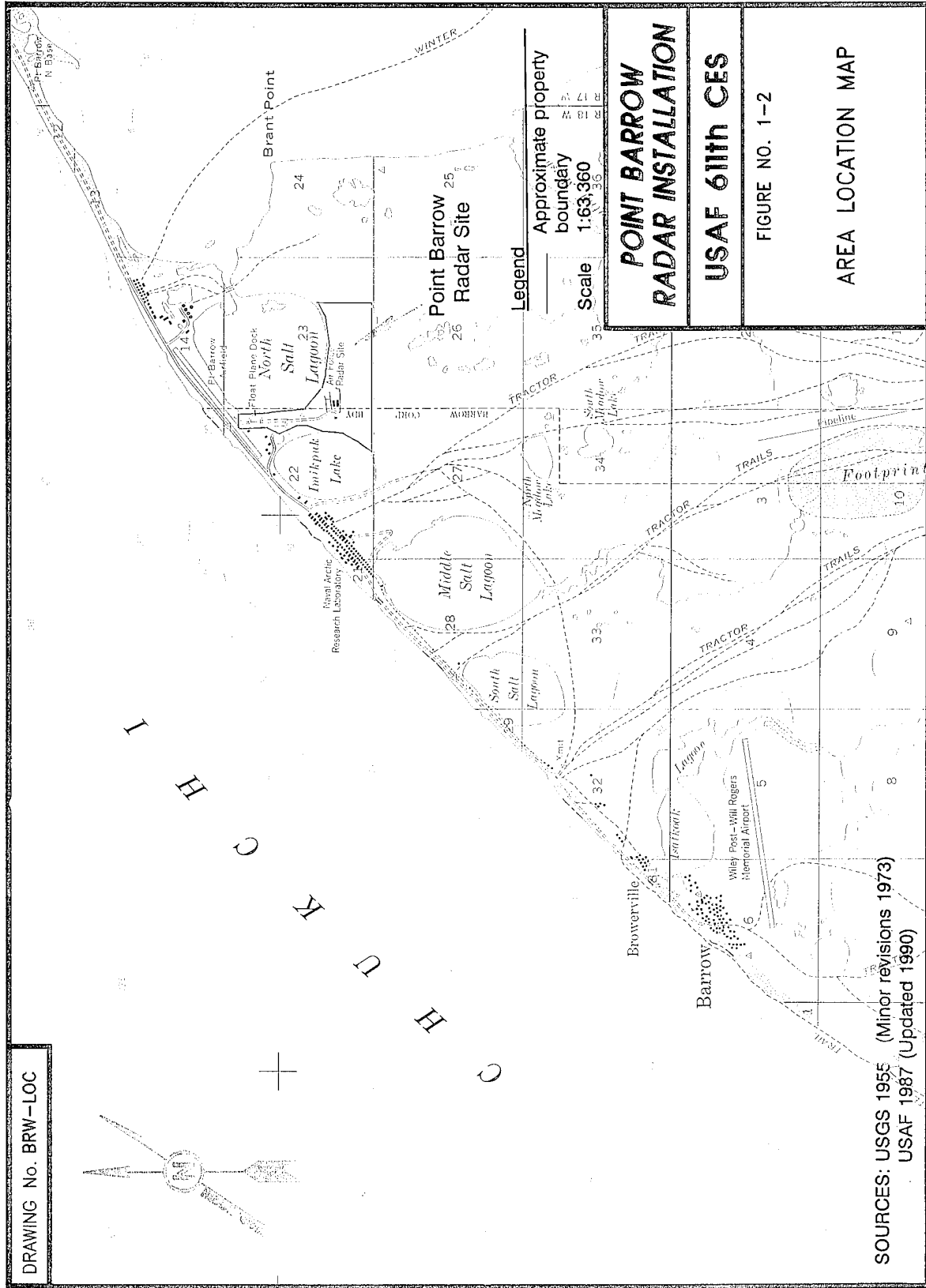
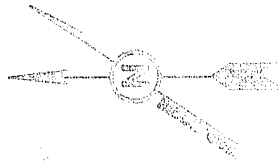
- *Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part A)* [U.S. Environmental Protection Agency (EPA) 1989a],
- Region 10 Supplemental Risk Assessment Guidance for Superfund (EPA 1991a),
- *Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual* (EPA 1989b),
- General Guidance for Ecological Risk Assessment at Air Force Bases (MITRE 1990),
- Handbook to Support the Installation Restoration Program (IRP) Statements of Work (Air Force 1991), and
- Framework for Ecological Risk Assessment (EPA 1992a).

1.3 INSTALLATION DESCRIPTION AND ENVIRONMENTAL SETTING

The Point Barrow DEW Line installation is located at 71°17'N, 156°45'W on the north slope of Alaska. The city of Barrow, Alaska, is located about five miles to the west. The Point Barrow installation was constructed as a main installation on a 268 acre site. The installation consists of two module trains, rotating radar, garage, warehouse, POL tanks, and logistics support facilities for the other DEW Line installations in the Point Barrow sector. The module trains house living quarters (including a dining room, kitchen, recreation area, showers, toilets, and water storage), administration offices, a mechanical room with an emergency boiler and fuel storage, and the electric equipment work areas and radar tower. The installation also has an inactive 4,993-foot long runway; air traffic for the installation uses the runway in the city of Barrow. An area location map is presented in Figure 1-2, and a site plan of the installation is shown in Figure 1-3.

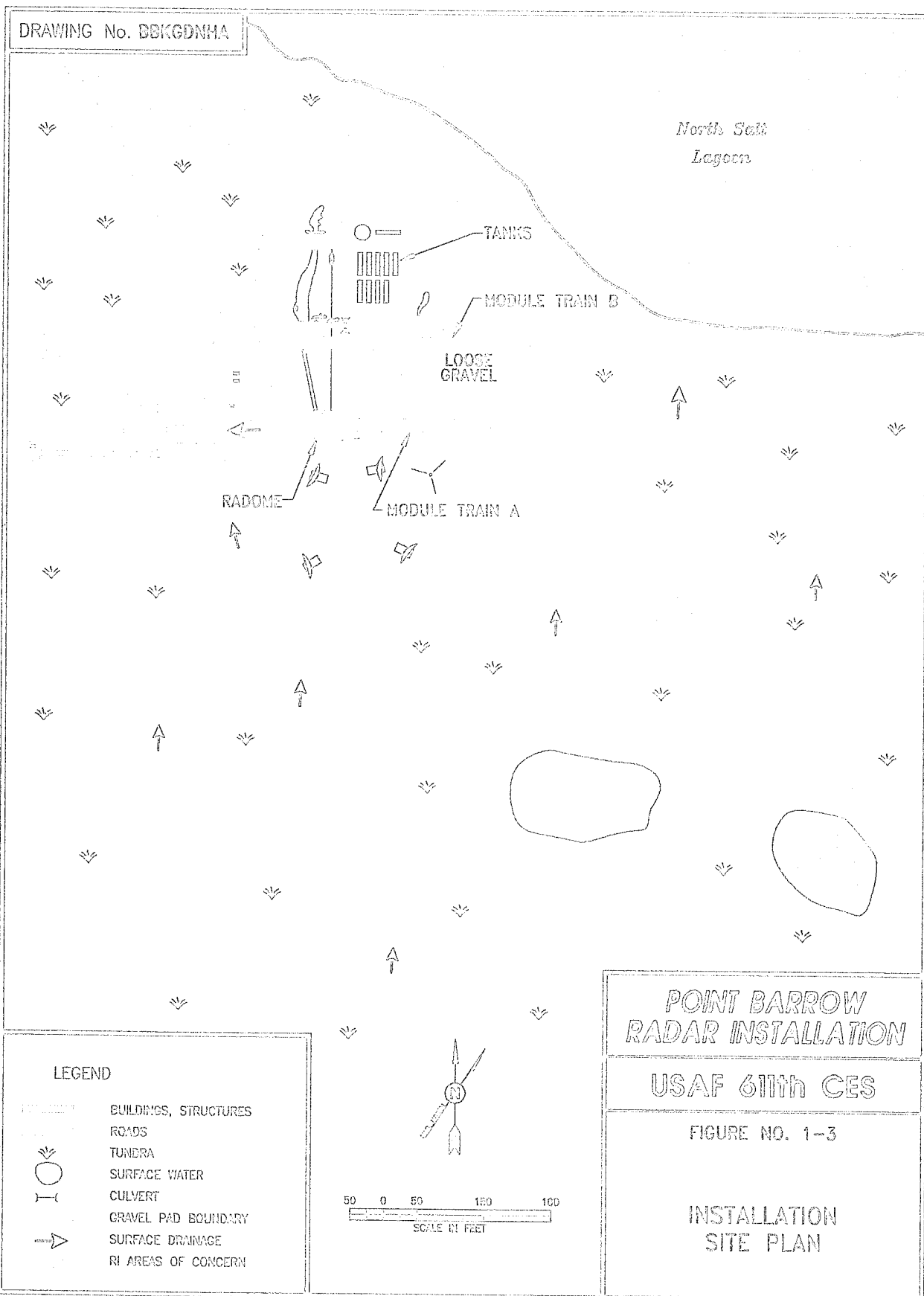
Geography, Geology, and Meteorology. The installation is at an elevation of eight feet above mean sea level between a large freshwater thaw lake (Imikpuk Lake) and a salt water lagoon (North Salt Lagoon) in an area dominated by coastal and thaw lake processes. Geologically, the area consists of marine clay, silt, and sand deposits. Permafrost underlies the entire installation.

DRAWING No. BRW-LOC



THIS PAGE INTENTIONALLY LEFT BLANK

DRAWING No. DDKGDNHA



THIS PAGE INTENTIONALLY LEFT BLANK

Permafrost comprises geologic, hydrologic, and meteorologic characteristics that result in permanently frozen ground. Permafrost occurs in both unconsolidated sediments and bedrock. Its distribution is continuous on the Arctic Coastal Plain, and it has a significant impact on the flow of ground and surface water.

Permafrost acts as an impermeable barrier to the movement of groundwater because pore spaces are ice-filled in the zone of saturation. Recharge and discharge are limited to unfrozen channels penetrating the permafrost zone. Permafrost restricts the downward percolation of water and increases runoff, enhancing the creation of lakes and swamps, and also restricts an aquifer's storage capacity and the number of locations from which groundwater may be withdrawn.

The interval between permafrost and ground surface is called the active zone because it freezes and thaws with seasonal weather changes. Water may be found in the active zone in the summer months. The thickness of the active zone at Point Barrow varies from one to six feet.

Surface water drainage occurs as a suprapermafrost sheet flow and shallow creek runoff into Elson Lagoon or the Chukchi Sea. Drainage in the southern portion of the facilities is relatively poor due to the flat topography and the high-centered polygons that have developed. Swampy areas occur to the south and east of the southern portion of the installation. North Salt Lagoon covers four acres with an outlet to Elson Lagoon. A fresh water lake covering 1.8 acres occurs west of, and provides some of the water for, the installation. High tides generated by storms sometimes traverse the sand bar separating the freshwater lake from the ocean and contaminate it with salt water. Another fresh water lake to the southwest of the installation also provides potable water.

Annual average precipitation at the Barrow installation is 4.9 inches, including 29 inches of snowfall. Most precipitation occurs as rain in the summer; from October to May, precipitation is generally snow. Easterly winds are persistent throughout the area at average speeds of 12 miles per hour. Only one percent of the hours recorded are calm. Heavy fog occurs frequently in the summer and reduces visibility to 0.25 miles 65 days per year.

Demographics. Approximately four contract personnel are stationed at the Point Barrow installation. Barrow is the largest community on the North Slope, and the population of the city of Barrow, Alaska, in 1993 was 3,908 (Harcharek 1994). Barrow is the seat of both the North Slope Borough (NSB) and the Arctic Slope Regional Corporation. The NSB assumes borough-wide responsibility for municipal services, including basic life, health, and safety.

The Point Barrow radar installation was investigated to evaluate possible contamination related to Air Force activities and historical waste disposal practices at the sites. Three sites at the Point Barrow radar installation were determined to be of potential concern based on previous IRP sampling activities, literature search, pre-survey and reconnaissance trips, interviews with station personnel, and information on disposal practices at DEW Line stations. The sites were investigated during RI/FS activities to confirm the presence or absence of chemical contamination; define the extent and magnitude of confirmed chemical releases; gather adequate data to determine the magnitude of potential risks to human health and the environment; and

gather adequate data to identify and select the appropriate remedial actions for sites where apparent risks exceed acceptable limits.

Three sites at the installation that were investigated during the RI were evaluated in the risk assessment. These sites include:

- **Diesel Fuel Spill (SS01).** The Diesel Fuel Spill (SS01) site is an approximately three acre area located north of module train "A". A 300-gallon spill occurred at the site in 1974; however, the exact location of the spill is unknown (CH2M Hill 1981). The site consists of two sections: a tundra area to the north adjacent to the POL storage area and a gravel pad area to the south adjacent to the west end of module train "B". The POL storage area in the north portion of the site is a bermed area that was used as a storage area for arctic grade diesel fuels from 1956 to 1978. In the south portion of the site, a gravel road raised approximately three feet above the tundra surrounds both module trains. There is a thin layer of gravel below both module trains, and the gravel next to the module trains is raised approximately one foot above the tundra. Culverts lead from below the module train north to the tundra area.
- **Garage (SS02).** The Garage (SS02) site is located west of module train "A". The Garage is an approximately 90-foot by 40-foot building elevated about three feet above the tundra and is surrounded by gravel on the north, east, and south sides. The building is used for vehicle maintenance and storage. Floor drains in this building discharged directly to the tundra beneath the structure and may have received vehicle maintenance waste. The floor drains were sealed by the Air Force in July 1993 to prevent the possibility of future release of contaminants.
- **Air Terminal Area (SS03).** This large area is located north-northwest of the main station facilities, around the air terminal building. The site consists of an expanse of gravel pads and roads which effectively berm off several wet tundra areas, a hangar, air terminal building, and several fuel storage tanks (JP-4 and diesel). A total of four fuel spills have been reported by a previous Navy contractor in areas just to the west of the site. The first occurred in August 1976 and consisted of an underground pipe failure that discharged an estimated 48,000 gallons of gasoline. The second and third reported spills occurred in 1978 and involved approximately 24,700 gallons of JP-5 (jet fuel) and 277,463 gallons of gasoline, respectively. A fourth spill of unknown quantity occurred in 1986 (Shannon and Wilson 1991).

Table 1-1 contains a summary of the environmental media sampled at each of the sites. The analytical data obtained from these samples form the basis of the human health and ecological risk assessments in this document. Figures of each of the sites are presented in Section 2.0.

1.4 APPROACH TO HUMAN HEALTH RISK ASSESSMENT

The Point Barrow DEW Line installation presents a unique challenge in the development of a human health risk assessment. Many of the conventional assumptions applied in risk assessments do not apply to the city of Barrow and the North Slope of Alaska. Native residents of the North Slope, in general, follow a lifestyle that includes a significant subsistence component; much of their food consists of mammals (whales, seals, and caribou), aquatic life (arctic char), and birds (ptarmigan and ducks) abundant in this area of the arctic. The climate is generally harsh, and the soil and surface water are frozen for approximately nine months of the year.

The general approach to the human health risk assessment was to quantify the excess lifetime cancer risk or the noncancer hazard for the site contaminants detected at each of the three sites at the installation. The maximum concentration of each chemical detected was used instead of an arithmetic mean or 95th percentile upper confidence limit (UCL) because contamination was detected infrequently and generally found to be of low concentration. Incorporating nondetects into the calculation of an average or UCL when the frequency of positive detects is low tends to yield low and unreliable estimates of contamination. Use of the maximum concentration yields a conservative estimate of risk or hazard.

To the extent possible, site-specific information was incorporated into the development of the exposure assumptions. The harsh climate naturally serves to limit exposure to contaminated soil, sediment, and surface water.

Residential exposure assumptions were used to reflect the upper-bound potential future risk. Several North Slope communities have requested use of inactive buildings at DEW Line installations; therefore, an evaluation using potential residential scenarios at the installations and sites was conducted.

Excess lifetime cancer risk and noncancer hazard were calculated for the soil/sediment ingestion and water ingestion pathways. Other pathways were eliminated from consideration as described in Section 2.2, Human Health Risk Exposure Assessment.

1.5 APPROACH TO ECOLOGICAL RISK ASSESSMENT

The objective of the ERA is to estimate potential impacts to aquatic and terrestrial plants and animals at the Point Barrow radar installation. MITRE (1990) suggests that ERAs should "estimate the potential for occurrence of adverse effects that are manifested as changes in the diversity, health and behavior" of ecosystems. MITRE proposes that this can be accomplished by:

- Estimating the health risk to individual species;
- Evaluating the health of the community of exposed species; and

- Determining the potential adverse effects of contamination over several life cycles of the species under study.

Because this is a screening level assessment, the scope of the ERA is limited to the first task: estimating the risk or hazard to individual species. If a potential risk or hazard to individual species was identified, further work may be recommended to evaluate the community and life cycle effects. It is important to note that the health risk to an individual species is different from the health risk to an individual within a species. The former refers to population level biology, where the individual is not considered a relevant endpoint. The latter assesses the risks to an individual. In this ecological assessment, the individual is considered only in the case of threatened or endangered species.

2.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The purpose of the baseline human health risk assessment for the Point Barrow DEW Line installation is to provide a basis for developing a risk management plan, including remedial action alternatives based on data from the RI/FS. The risk assessment develops numerical estimates of cancer risk and noncancer hazard for each site where sufficient information is available. Where information is not adequate to quantify noncancer hazard or cancer risk for a given COC, a qualitative discussion of the toxicity of that COC is provided in the Toxicity Profiles (Appendix B).

This baseline human health risk assessment addresses issues unique to this location as described in the introduction. It is comprised of six sections:

- Identification of COCs - in which the chemicals detected in environmental samples are compared to risk-based screening levels (RBSLs) and concentrations considered to be applicable or relevant and appropriate requirements (ARAR);
- Exposure assessment - in which the frequency, duration, and magnitude of potential exposures to the COCs are estimated;
- Toxicity assessment - in which the toxicology of the COCs is assessed;
- Risk characterization - in which the potential for adverse health effects in humans as a result of exposure to the COCs is quantified (as appropriate) or qualitatively discussed;
- Uncertainty assessment - in which the general sources of uncertainty in the risk assessment process and the site-specific sources of uncertainty are discussed; and
- Risk Assessment Summary and Conclusions - in which the human health risks are summarized for each of the sites and conclusions based on these risks are presented.

2.1 IDENTIFICATION OF CHEMICALS OF CONCERN

Chemicals of potential concern to human health were selected for each site at the Point Barrow installation based on comparison of chemical concentrations to RBSLs, naturally-occurring background concentrations, ARARs, and safe levels of essential human nutrients (e.g., calcium, magnesium, sodium, and potassium).

This section discusses the RI sampling strategy and an evaluation of data prior to screening (Section 2.1.1), describes and presents equations for calculating RBSLs (Section 2.1.2), identifies

chemicals that are essential human nutrients (Section 2.1.3), describes the collection of background samples (Section 2.1.4), and discusses the selection of COCs (Section 2.1.5).

2.1.1 Sampling Strategy and Evaluation of Analytical Data

The RI sampling strategy at the Point Barrow sites was to characterize the nature and extent of potential contamination at each site. Suspected source areas were sampled to determine the concentrations of contaminants, if any, at the areas likely to have the highest concentrations. Migration pathways from the source areas were sampled to determine the extent, if any, that the contaminants had migrated from the sites. If no discernable pathways were evident, an attempt was made to sample around the source areas to determine the extent of site contaminants. Quick turn-around analyses were conducted on samples from the first sampling event, and a second round of sampling was conducted at those sites where further characterization of the nature and extent of contamination was needed.

Sample types included surface and subsurface soil/sediment samples and surface water samples. In almost all cases, samples were discrete grab samples from one sample location. Surface soil and sediment samples were collected in gravel and tundra areas at or near the ground surface (from ground surface to approximately six inches in depth). Subsurface soil samples were mainly collected in gravel pad areas where unsaturated conditions allowed vertical migration of contaminants. Sediment samples were collected below shallow ponds or streams, or in areas that visually appeared to have been previously covered with water. Surface water samples were collected from ponds, streams, springs, or leachate areas. Surface water samples underwent both total and dissolved metal analyses; however, the total metal analytical results were used in the risk assessment. A summary of the 1993 RI sampling and analyses conducted at the installation is presented in Appendix G.

Before screening for COCs, the results of the RI sampling program were sorted by medium (i.e., soil, sediment, and surface water) and reviewed for quality. The review included an evaluation of the analytical methods used, the sample quantitation limits, and qualified data, and a comparison to background levels and laboratory and field blanks. Analytical data were reviewed for completeness, comparability, representativeness, precision, and accuracy. In addition, data validation qualifiers were considered in assessing the quality of the data. The review and validation of analytical data determined that a minimal amount of data was not usable. These data were qualified with an "R" and were not used in the risk assessment.

As outlined in the Risk Assessment Guidance for Superfund (EPA 1989a), site data were compared to available blank (laboratory, field, and trip) data. The data from blanks are presented in Appendix G. In accordance with EPA (1989a), if the detected concentration in a sample was less than 10 times the concentration from blanks for common laboratory contaminants (e.g., acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters) the chemical was not selected for evaluation in the risk assessment. For those organic or inorganic chemicals that are not considered by EPA to be common laboratory contaminants (all other compounds), if the detected concentration was less than five times the maximum concentration detected in the blanks, the chemical was not selected for evaluation in the risk assessment.

2.1.2 Risk-Based Screening Levels

An RBSL is a chemical concentration in a particular medium that yields a given cancer risk or hazard quotient (HQ) (e.g., 10^{-7} cancer risk or 0.1 HQ) under a given set of conditions. For Point Barrow, the RBSLs were calculated for soil based on EPA default reasonable maximum exposure (RME) parameters (EPA 1991a). In developing the RBSLs, the most recent toxicity factors available from the Integrated Risk Information System (IRIS) and the Health Effects Assessment Summary Tables (HEAST) were used. IRIS and HEAST are databases of toxicity information for human health risk assessment maintained by the Environmental Criteria and Assessment Office (ECAO) of the EPA. The information presented on IRIS represents the Agency's consensus regarding the toxicity of chemicals released to the environment. Toxicity factors that EPA has withdrawn from IRIS and HEAST, or available from other sources were not used in this risk assessment.

2.1.2.1 Formulae for Calculating RBSLs. The RBSL concentrations were derived using EPA Region 10 guidance (EPA 1991a). The equations are also presented in a slightly different form in the Risk Assessment Guidance for Superfund Volume I, Part B (EPA 1991b). Exposure assessment and risk characterization algorithms for human health risk assessments use site-specific contaminant concentration data, factors describing exposure, and toxicity dose-response values (e.g., reference doses or carcinogen slope factors). These risk assessment algorithms were solved for the concentration term to derive the RBSL for soil and surface water. The algorithms are summarized as follows:

$$\text{Risk} = C \times \left(\frac{\text{CR} \times \text{EFD}}{\text{BW} \times \text{AT}} \right) \times \text{SF} \quad \text{or} \quad \text{HQ} = C \times \left(\frac{\text{CR} \times \text{EFD}}{\text{BW} \times \text{AT}} \right) / \text{RfD} \quad \text{EQUATION 1, 2}$$

Risk = Target Cancer Risk

C = Concentration

CR = Contact Rate

EFD = Exposure Frequency and Duration

BW = Body Weight

AT = Averaging Time

SF = Slope Factor

HQ = Target Hazard Quotient

RfD = Reference Dose

RBSLs are calculated based on a specific target cancer risk or HQ. EPA (1991a) recommends that a 1×10^{-7} target cancer risk and a target noncancer HQ of 0.1 be used for soil and a 1×10^{-6} risk and 0.1 HQ be used for surface water. The lower target cancer risk is used for screening soil because additional pathways, such as dermal contact and inhalation, are not accounted for by the calculations (EPA 1991a).

Equations (1) and (2) shown above are rearranged to solve for the concentration term (i.e., the RBSL):

$$C = \text{Risk} / \left(\left(\frac{\text{CR} \times \text{EFD}}{\text{BW} \times \text{AT}} \right) \times \text{SF} \right) \quad \text{or} \quad C = \text{HQ} / \left(\left(\frac{\text{CR} \times \text{EFD}}{\text{BW} \times \text{AT}} \right) / \text{RfD} \right) \quad \text{EQUATION 3, 4}$$

Surface Water Ingestion Equations. Using standard default exposure factors (EPA 1989b) for water ingestion, the equation for cancer risk from drinking water ingestion becomes:

$$\text{Risk} = C (\mu\text{g/L}) \times 0.001 \text{ mg}/\mu\text{g} \times \left(\frac{2 \text{ L/day} \times 350 \text{ day/year} \times 30 \text{ year}}{70 \text{ kg} \times 70 \text{ year} \times 365 \text{ day/year}} \right) \times \text{SF}_o \quad \text{EQUATION 5}$$

Equation (5) can be rearranged to solve for an RBSL with, for example, a target cancer risk of 10^{-6} :

$$C (\mu\text{g/L}) = 10^{-6} \times 1,000 \mu\text{g}/\text{mg} / \left[\left(\frac{2 \text{ L/day} \times 350 \text{ day/year} \times 30 \text{ year}}{70 \text{ kg} \times 70 \text{ year} \times 365 \text{ day/year}} \right) \times \text{SF}_o \right] \quad \text{EQUATION 6}$$

For non-carcinogens, the equation for the HQ for drinking water ingestion is:

$$\text{HQ} = C (\mu\text{g/L}) \times 0.001 \text{ mg}/\mu\text{g} \times \left(\frac{2 \text{ L/day} \times 350 \text{ day/year} \times 30 \text{ year}}{70 \text{ kg} \times 30 \text{ year} \times 365 \text{ day/year}} \right) / \text{RfD}_o \quad \text{EQUATION 7}$$

Equation (7) can be rearranged to provide an equation for the concentration that represents an HQ of one from ingestion:

$$C (\mu\text{g/L}) = 1 \times 1,000 \mu\text{g}/\text{mg} / \left[\left(\frac{2 \text{ L/day} \times 350 \text{ day/year} \times 30 \text{ year}}{70 \text{ kg} \times 30 \text{ year} \times 365 \text{ day/year}} \right) / \text{RfD}_o \right] \quad \text{EQUATION 8}$$

Soil or Sediment Ingestion Equations. The equation for calculating carcinogenic risk from soil or sediment ingestion, combining child (subscript c) and adult (subscript a) exposure, is as follows:

$$\text{Risk} = C (\text{mg}/\text{kg}) \times 0.000001 \text{ kg}/\text{mg} \times \quad \text{EQUATION 9}$$

$$\left[\left(\frac{200_c \text{ mg/day} \times 350_c \text{ day/year} \times 6 \text{ year}}{15_c \text{ kg} \times 365 \text{ day/year}} \right) + \left(\frac{100_a \text{ mg/day} \times 350_a \text{ day/year} \times 24 \text{ year}}{70_a \text{ kg} \times 365 \text{ day/year}} \right) \right] / 70 \text{ year} \times \text{SF}_o$$

Equation (9) can be rearranged to solve for the concentration that represents a target cancer risk of 10^{-7} :

$$C (\text{mg}/\text{kg}) = 10^{-7} \times 1,000,000 \text{ kg}/\text{mg} / \quad \text{EQUATION 10}$$

$$\left[\left(\frac{200_c \text{ mg/day} \times 350_c \text{ day/year} \times 6 \text{ year}}{15_c \text{ kg} \times 365 \text{ day/year}} \right) + \left(\frac{100_a \text{ mg/day} \times 350_a \text{ day/year} \times 24 \text{ year}}{70_a \text{ kg} \times 365 \text{ day/year}} \right) \right] / 70 \text{ year} \times \text{SF}_o$$

For non-carcinogens in soil, Equation (11) is used to calculate the HQ:

$$HQ = C \text{ (mg/kg)} \times 0.000001 \text{ kg/mg} \times$$

EQUATION 11

$$\left[\left(\frac{200_c \text{ mg/day} \times 350_c \text{ day/year} \times 6 \text{ year}}{15_c \text{ kg} \times 365 \text{ day/year}} \right) + \left(\frac{100_a \text{ mg/day} \times 350_a \text{ day/year} \times 24 \text{ year}}{70_a \text{ kg} \times 365 \text{ day/year}} \right) / 30 \text{ year} \right] / RfD_o$$

Equation (11) can be rearranged to solve for the concentration that represents an HQ of 0.1:

$$C \text{ (mg/kg)} = 0.1 \times 1,000,000 \text{ mg/kg} /$$

EQUATION 12

$$\left[\left(\left(\left(\frac{200_c \text{ mg/day} \times 350_c \text{ day/year} \times 6 \text{ year}}{15_c \text{ kg} \times 365 \text{ day/year}} \right) + \left(\frac{100_a \text{ mg/day} \times 350_a \text{ day/year} \times 24 \text{ year}}{70_a \text{ kg} \times 365 \text{ day/year}} \right) \right) / 30 \text{ year} \right) / RfD_o \right]$$

2.1.3 Screening of Chemicals by Comparing Maximum Detected Concentrations of Essential Human Nutrients

Based on EPA's guidance (1991a), calcium, magnesium, potassium, iron, and sodium are considered to be essential human nutrients and were eliminated from the human health risk assessment at the screening stage. These chemicals are often detected but are not toxic to humans except at extremely high doses. No quantitative toxicity information is available for these elements from EPA sources; therefore, these metals are not selected as COCs for this risk assessment.

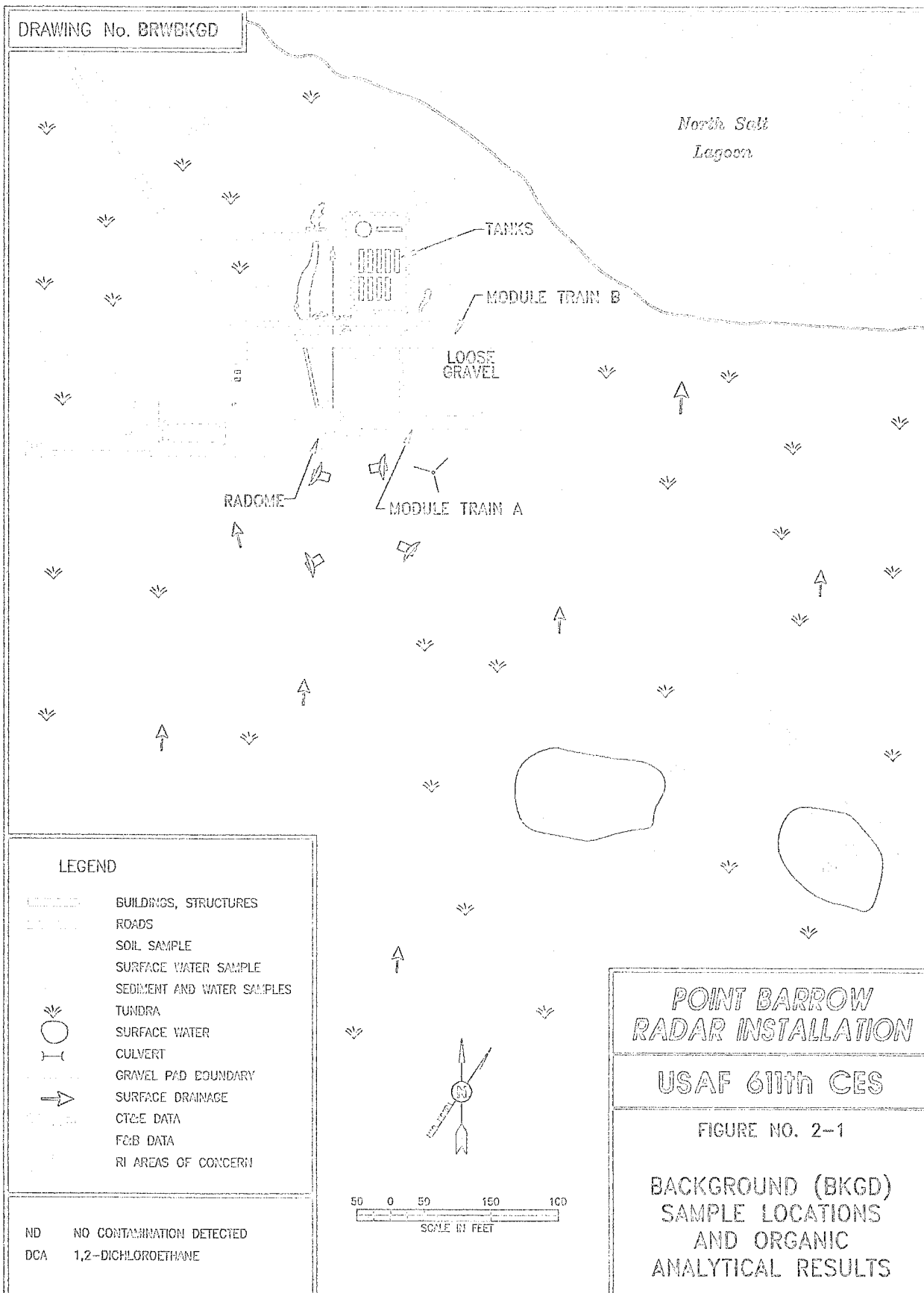
2.1.4 Concentrations of Organic and Inorganic Constituents in Background Samples

Four soil, one sediment, and two surface water samples were collected upgradient of the radar installation to determine the concentrations of naturally occurring organic constituents in soil, sediment, and surface water (Figure 2-1). Soil and sediment background samples were collected at a depth of zero to six inches.

In order to obtain a representative range of background inorganic (metal) concentrations in soil, sediment, and surface waters of the North Slope, 44 samples (29 soil or sediment, and 15 water) from seven North Slope radar installations were collected and analyzed. The seven installations include Barter Island, Bullen Point, Oliktok Point, Point Lonely, Point Barrow, Point Lay, and Wainwright. Approximately four soil or sediment and two surface water background samples were collected and analyzed for metals at each of the seven radar installations. In determining potential risks in surface water, total metal concentrations were used in the risk assessment. Analytical results for background samples collected at Point Barrow are presented in Appendix G.

THIS PAGE INTENTIONALLY LEFT BLANK

DRAWING No. BRWBKGD



THIS PAGE INTENTIONALLY LEFT BLANK

2.1.5 Selection of Chemicals of Concern

Soil and Sediment. The maximum concentrations of the chemicals detected in soil or sediment samples at the Point Barrow installation and not considered to be essential human nutrients were compared, on a site-by-site basis, to the corresponding background concentrations, RBSLs, and where available, federal or state ARARs. Chemicals detected without an RBSL or ARAR were retained as COCs if concentrations exceeded background levels. A chemical with an RBSL or ARAR was selected as a COC for soil and sediment if the maximum concentration at which the chemical was detected exceeded the corresponding background concentration and the RBSL (based either on cancer risk or noncancer hazard) or ARAR (Table 2-1). Thus, for example, the maximum concentration of diesel range petroleum hydrocarbons (DRPH) at the Diesel Fuel Spill (SS01), 3,960 mg/kg, exceeds the background range and the state ARAR of 500 mg/kg. Therefore, DRPH were selected as a COC for the soils at the Diesel Fuel Spill site.

The COCs for soil/sediment at each site were compared to background concentrations, RBSLs, and ARARs in Table 2-1. The chemicals retained as COCs exceed background concentrations, the RBSL, or an ARAR. A chemical was not retained if the level detected was less than the corresponding RBSL and ARAR, even though background levels were exceeded. The COCs selected that do not have an RBSL or an ARAR are discussed below. The COCs selected at each site that exceed an RBSL, ARAR, or both, are discussed in Sections 2.1.5.1 to 2.1.5.3.

Surface Water. The maximum concentrations of the chemicals detected in surface water samples at the Point Barrow installation were compared, on a site-by-site basis, to the corresponding background concentrations, RBSLs, and where available, federal or state ARARs. Chemicals detected without an RBSL or ARAR were retained as COCs if concentrations exceeded background levels. A chemical with an RBSL or ARAR was selected as a COC for surface water if the maximum concentration at which the chemical was detected exceeded the corresponding background concentration, and the RBSL (based either on cancer risk or noncancer hazard) or ARAR (Table 2-1). Thus, for example, the maximum concentration of gasoline range petroleum hydrocarbons (GRPH) in surface water, at the Diesel Fuel Spill (SS01) site, 1,690 µg/L, exceeds the background concentration of <50 µg/L (not detected) and the RBSLs based on cancer risk (50 µg/L) and noncancer hazard (730 µg/L). Therefore, GRPH was selected as a COC for the surface water at the Diesel Fuel Spill site.

The COCs for surface water at each site were compared to background concentrations, RBSLs, and ARARs in Table 2-1. The chemicals retained as COCs exceed background concentrations and the RBSL or an ARAR. A chemical was not retained if the level detected was less than the corresponding RBSL and ARAR, even though background levels were exceeded. The COCs selected that exceed background levels, but do not have an RBSL or ARAR are discussed below. The COCs at each site that exceed an RBSL, ARAR, or both, are discussed in Sections 2.1.5.1 to 2.1.5.3.

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT POINT BARROW

SITE	MATRIX	CHEMICAL DETECTED ^k	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL ^a		ARAR ^b	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
Diesel Fuel Spill (SS01)	Soil	DRPH	3,960	mg/kg	<65J-<180J	--	--	500 ^c	Yes
		GRPH	210J	mg/kg	<3J-<7J	--	--	100 ^c	Yes
		Benzene	0.17J	mg/kg	<0.03-<0.07	2.21	--	0.5 ^c	No
		Toluene	1.5	mg/kg	<0.03-<0.07	--	5,400	--	No
		Ethylbenzene	3.7	mg/kg	<0.03-<0.07	--	2,700	--	No
		Xylenes (Total)	14J	mg/kg	<0.05-<0.1	--	54,000	--	No
		1,2,4-Trimethylbenzene	0.903	mg/kg	<0.050J	--	--	--	Yes*
		1,3,5-Trimethylbenzene	0.396	mg/kg	<0.050J	--	--	--	Yes*
		GRPH	1,690	µg/L	<50J	50	730	--	Yes
		Benzene	9	µg/L	<1	0.617	--	5 ^e	Yes
		Toluene	42J	µg/L	<1	--	96.5	1,000 ^f	No
		Ethylbenzene	14J	µg/L	<1	--	158	700 ^f	No
		Xylenes (Total)	380J	µg/L	<2	--	7,300	10,000 ^f	No
		sec-Butylbenzene	1.5	µg/L	<1	--	--	--	Yes*
		Isopropylbenzene	4.8	µg/L	<1	--	--	--	Yes*
Garage (SS02)	Soil	p-Isopropyltoluene	4.0	µg/L	<1	--	--	--	Yes*
		Naphthalene	58	µg/L	<1	--	150	--	No
		n-Propylbenzene	4.1	µg/L	<1	--	--	--	Yes*
		1,2,4-Trimethylbenzene	92	µg/L	<1	--	--	--	Yes*
		1,3,5-Trimethylbenzene	52	µg/L	<1	--	--	--	Yes*
		DRPH	3,300J	mg/kg	<65J-<180J	--	--	500 ^c	Yes
		GRPH	113J	mg/kg	<3J-<7J	--	--	100 ^c	Yes
		RRPH	710	mg/kg	<130-<360	--	--	2,000 ^c	No
		Toluene	1.3	mg/kg	<0.03-<0.07	--	5,400	--	No

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT POINT BARROW (CONTINUED)

SITE	MATRIX	CHEMICAL DETECTED ^k	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL ^a		ARAR ^b	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
Garage (SS02) (Continued)	Soil (Continued)	Ethylbenzene	0.9	mg/kg	<0.03-<0.07	--	2,700	--	No
		Xylenes (Total)	6.9J	mg/kg	<0.05-<0.1	--	54,000	--	No
		Tetrachloroethene	0.3	mg/kg	<0.03-<0.07	1.23	270	--	No
		Trichloroethene	0.6	mg/kg	<0.03-<0.07	5.8	--	--	No
		Styrene	0.187	mg/kg	<0.050J	--	--	--	Yes*
		Aroclor 1254	14	mg/kg	<0.4J	0.00831	0.54	10 ^g	Yes
		Aluminum	1,000	mg/kg	1,500-23,000	--	--	--	No
		Barium	110	mg/kg	27-390	--	1,890	--	No
		Cadmium	3.9	mg/kg	<3.0-<27	--	27	--	No
		Calcium	1,200	mg/kg	360-59,000	--	--	--	No
		Chromium	31	mg/kg	<4.3-47	--	135	--	No
		Copper	20	mg/kg	<2.7-45	--	999	--	No
		Iron	7,600	mg/kg	5,400-35,000	--	--	--	No
		Lead	150	mg/kg	<5.1-22	--	--	400 ^h	No
		Magnesium	650	mg/kg	360-7,400	--	--	--	No
		Manganese	45	mg/kg	25-290	--	3,780	--	No
		Nickel	5.2	mg/kg	4.2-46	--	540	--	No
		Potassium	350	mg/kg	<300-2,200	--	--	--	No
		Sodium	100	mg/kg	<160-680	--	--	--	No
		Vanadium	8.1	mg/kg	6.3-59	--	189	--	No
		Zinc	270	mg/kg	9.2-95	--	8,100	--	No
		DRPH	11,000J	mg/kg	<65J-<180J	--	--	500 ^c	Yes
		GRPH	1,200J	mg/kg	<3J-<7J	--	--	100 ^c	Yes
Air Terminal Area (SS03)	Soil								

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT POINT BARROW (CONTINUED)

SITE	MATRIX	CHEMICAL DETECTED ^a	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL ^a		APAR ^b	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
Air Terminal Area (SS03) (Continued)	Soil (Continued)	RRPH	120	mg/kg	<130-<360	--	--	2,000 ^c	No
		Benzene	0.35	mg/kg	<0.03-<0.07	--	--	0.5 ^c	No
		Toluene	5.3	mg/kg	<0.03-<0.07	--	5,400	--	No
		Ethylbenzene	1.4J	mg/kg	<0.03-<0.07	--	2,700	--	No
		Xylenes (Total)	7.1J	mg/kg	<0.05-<0.1	--	54,000	--	No
		Naphthalene	1.87J	mg/kg	<3.80-<40.0	--	100	--	No
		2-Methylnaphthalene	2.58	mg/kg	<3.80-<40.0	--	--	--	Yes*
		Aluminum	1,900	mg/kg	1,500-25,000	--	--	--	No
		Arsenic	9.7	mg/kg	<4.9-<7.0	0.0366	8.1	--	Yes
		Barium	70	mg/kg	27-390	--	1,890	--	No
		Calcium	2,200	mg/kg	360-59,000	--	--	--	No
		Chromium	25	mg/kg	<4.3-47	--	135	--	No
		Copper	4.3	mg/kg	<2.7-45	--	999	--	No
		Iron	9,000	mg/kg	5,400-35,000	--	--	--	No
		Lead	140	mg/kg	<5.1-22	--	--	400 ^h	No
		Magnesium	1,500	mg/kg	360-7,400	--	--	--	No
		Manganese	30	mg/kg	25-290	--	3,780	--	No
		Nickel	5.4	mg/kg	4.2-46	--	540	--	No
		Potassium	610	mg/kg	<300-2,200	--	--	--	No
		Sodium	200	mg/kg	<160-680	--	--	--	No
		Vanadium	13	mg/kg	6.3-59	--	189	--	No
		Zinc	56	mg/kg	9.2-95	--	8,100	--	No

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT POINT BARROW (CONTINUED)

SITE	MATRIX	CHEMICAL DETECTED [*]	MAXIMUM CONCENTRATION	UNITS	BACKGROUND RANGE	RBSL ^a		ARAR ^b	CHEMICAL OF CONCERN
						CANCER	NON-CANCER		
Air Terminal Area (SS03) (Continued)	Surface Water	GRPH	1,126J	µg/L	<50J	50	730	--	Yes
		Benzene	83	µg/L	<1	0.617	--	5 ^e	Yes
		Toluene	74	µg/L	<1	--	96.5	1,000 ^f	No
		Ethylbenzene	21	µg/L	<1	--	158	700 ^f	No
		Xylenes (Total)	280	µg/L	<2	--	7,300	10,000 ^f	No
		Naphthalene	4.2	µg/L	<1	--	150	--	No
		1,2-Dichloroethane	1.6J	µg/L	1.2	0.934	--	5 ^e	No
		1,2,4-Trimethylbenzene	8.9	µg/L	<1	--	--	--	Yes*
		1,3,5-Trimethylbenzene	3.5	µg/L	<1	--	--	--	Yes*
		Barium	120	µg/L	<50-93	--	256	2,000 ^j	No
		Calcium	41,000	µg/L	4,500-88,000	--	--	--	No
		Iron	6,000	µg/L	180-2,800	--	--	--	No
		Magnesium	42,000	µg/L	2,900-53,000	--	--	--	No
		Manganese	160	µg/L	<50-510	--	18.3	--	No
		Potassium	10,000	µg/L	<5,000	--	--	--	No
		Sodium	160,000	µg/L	8,400-410,000	--	--	--	No

* Chemicals without an RBSL or ARAR are considered chemicals of potential concern and are discussed in Section 2.1.5.

^a Risk-Based Screening Levels.

^b Applicable or Relevant and Appropriate Requirements.

^c Target cleanup levels for DRPH, GRPH, and RRPH in soil are based on ADEC Non-UST guidance and do not necessarily correspond to final site specific cleanup goals.

^d 55 FR 30798, Proposed Rule Resource Conservation and Recovery Act (RCRA) Corrective Action for SWMUs 40 CFR [Section 264.521 (a)(2)(i-iv)], Health-Based Criteria for

Systematic Toxicant.

^e MCL, 52 FR 25690.

^f MCL, 56 FR 3526 (30 January 1991).

^g TSCA Cleanup Level.

TABLE 2-1. IDENTIFICATION OF CHEMICALS OF CONCERN: COMPARISON OF MAXIMUM CONCENTRATIONS TO RISK-BASED SCREENING LEVELS, ARARS, AND BACKGROUND EVALUATION OF CHEMICALS DETECTED AT POINT BARROW (CONTINUED)

h	EPA 1994a.
i	MCL, 56 FR 30266 (01 July 1991).
j	Compound was not detected onsite at levels significantly (5x) above levels detected in blank samples.
k	Metal concentrations in surface water are results from total metal analyses.
l	Cancer RBSL for Aroclor 1254 is based on the cancer slope factor for PCBs (IRIS 1995).
j	Result is an estimate.
u	Compound is not present above the concentration listed.

Risk Characterization of Chemicals without RBSLs and ARARs. Several chemicals detected above background levels could not be thoroughly screened because an RBSL could not be calculated and no ARAR was available (Table 2-1). The cancer risk and noncancer hazard for these chemicals cannot, therefore, be quantified. A list of these chemicals is presented in Table 2-2.

This section is a qualitative discussion of the potential for these chemicals to cause toxicity among the receptor groups identified at the Point Barrow installation. The essential human nutrients were discussed in Section 2.1.3 and will not be discussed further here. Essential nutrients are not considered COCs in this risk assessment.

TABLE 2-2. CHEMICALS WITHOUT RBSLS AND ARARS OBSERVED IN THE SOIL, SEDIMENT, OR SURFACE WATER AT THE POINT BARROW INSTALLATION

SUBSTITUTED BENZENES	
1,2,4-Trimethylbenzene	
1,3,5-Trimethylbenzene	
p-Isopropyltoluene	
Isopropylbenzene	
n-Propylbenzene	
sec-Butylbenzene	
Styrene	
ESSENTIAL HUMAN NUTRIENTS	
Calcium	
Iron	
Magnesium	
Potassium	
Sodium	
POLYCYCLIC AROMATIC HYDROCARBONS	
2-Methylnaphthalene	
OTHER	
Aluminum	

The American Petroleum Institute (API) recently published an evaluation of the environmental fate, transport, and toxicity of twelve organic chemicals found frequently in petroleum products. The twelve were selected from a large list of "candidates" based on:

- abundance in crude and refined petroleum products, including residual and used oils;
- chemical/physical properties that represent a range of mobilities in soil and solubilities in aqueous environments; and
- toxicity in mammals and aquatic organisms (API 1994).

Two of the chemicals detected at the Point Barrow installation, 1,2,4-trimethylbenzene and naphthalene were selected from the list of twelve chemicals (API 1994) and are used in this risk assessment as surrogates for the chemicals without RBSLs and ARARs. These chemicals have similar chemical structures and, therefore, will represent the substituted benzenes and the polynuclear aromatic hydrocarbons that do not have toxicity criteria (Table 2-2).

1,2,4-Trimethylbenzene has a low order of toxicity in mammals (API 1994). No effect was observed on the kidneys of rats that received 0.5 or 2.0 g/kg orally five days per week for four weeks. Inhalation of high concentrations of 1,2,4-trimethylbenzene produces central nervous system depression in humans and rats. Lung toxicity, including bronchitis, pneumonitis, and edema, was also observed in humans. 1,2,4-Trimethylbenzene has not been observed to be carcinogenic or mutagenic in laboratory studies of rats and cultured mammalian cells. Potential exposure of receptors to 1,2,4-trimethylbenzene at the Point Barrow installation would probably be limited to oral ingestion of soil and at the maximum concentration measured (0.903 mg/kg soil) would be expected to be nontoxic.¹ For the purposes of this risk assessment, 1,2,4-trimethylbenzene is considered to be a reasonable surrogate for the substituted benzenes observed at the Point Barrow installation.

Because of the lack of toxicology information available for 2-methylnaphthalene, naphthalene will be used as a surrogate in this discussion of chemicals without RBSLs and ARARs. Naphthalene has a low order of toxicity in mammals (API 1994). The toxicology of this chemical has been well characterized in several species, including humans, rats, rabbits, and mice. The toxicity in humans is known from cases of accidental or intentional (suicide) ingestion of contaminated food or mothballs, and the most common effect is liver damage (jaundice) and destruction of red blood cells resulting in anemia. These effects occur at exposure levels that far exceed the levels to which the receptor groups at the Point Barrow installation could be exposed. Dose-response information is available from studies in rats, mice, and rabbits. High doses of naphthalene administered over several days to one month resulted in cataract formation and other less serious ocular effects. High doses administered over several days to three months produced

¹ Based on the following calculation: assume average daily soil ingestion rate of 200 mg of soil per day and 0.903 mg of 1,2,4-trimethylbenzene per kg of soil (maximum concentration measured at Point Barrow installation). This yields a dose of 0.000003 mg of 1,2,4-trimethylbenzene per kg body weight per day. The oral dose of 1,2,4-trimethylbenzene received by rats that showed no kidney effects was equivalent to 2,000 mg of 1,2,4-trimethylbenzene per kg body weight, which is more than 667,000,000 times greater than the estimated dose for potential receptors at the Point Barrow installation.

mild toxic effects on the liver, lung, kidney, and immunological system. The no effect level of oral exposure in these species occurs in the range of 100 to 300 mg naphthalene per kg body weight per day (100 to 300 mg/kg/day). The oral exposure levels to 2-methylnaphthalene that may occur through soil ingestion at the Point Barrow installation are in the range of 0.00001 to 0.00004 mg/kg/day. Furthermore, the maximum concentration of 2-methylnaphthalene is less than the RBSL for naphthalene. Therefore, any exposure to 2-methylnaphthalene in the soil or surface water at the Point Barrow installation is expected to be nontoxic.²

Aluminum, which is listed in the "Other" category, is the most abundant metal in the earth's crust (Lindsay 1979) and the concentrations measured (maximum concentration 1,900 mg/kg) were below the range generally expected in the lithosphere (10,000-300,000 mg/kg). Because the general population does not suffer aluminum toxicity, the concentration of aluminum in the soil at Point Barrow does not appear to present a health hazard.

In conclusion, the chemicals discussed above have been marked in Table 2-1 as COCs to indicate that there is some uncertainty in screening out these chemicals. Without toxicity criteria the potential risks of these chemical cannot be quantified. However, based on the information presented above, and the concentrations measured at the sites, these chemicals are not expected to pose a health risk.

Chemicals with RBSLs and/or ARARs. Following are discussions of the COCs at each site that exceeded background levels and an RBSL, ARAR, or both. The site figures in Sections 2.1.5.1 through 2.1.5.3 present all organic compounds detected at the sites and inorganic analytes that exceeded background levels and an associated RBSL or ARAR. Table 2-3 is a summary of the COCs selected for the sites at the Point Barrow installation.

2.1.5.1 Diesel Fuel Spill (SS01). DRPH and GRPH were identified as COCs for the soil matrix at the Diesel Fuel Spill site (Figure 2-2). The maximum concentrations of DRPH and GRPH exceeded their background concentrations and the ARAR concentrations for petroleum hydrocarbon contamination of soil (ADEC 1991) (Table 2-1).

GRPH and benzene were identified as COCs for the surface water at the site (Figure 2-2). GRPH exceeded the background concentration and the RBSLs based on cancer risk and noncancer hazard. Benzene exceeded the background concentration, the RBSL based on cancer risk, and the ARAR which is a maximum contaminant level (MCL) promulgated under the federal Safe Drinking Water Act (Table 2-1).

2.1.5.2 Garage (SS02). DRPH, GRPH, and Aroclor 1254 were identified as COCs for the soil matrix at the Garage (Figure 2-3). The concentrations of DRPH and GRPH exceeded their background concentrations and the ARAR concentration for petroleum hydrocarbon contamination of soil (ADEC 1991) (Table 2-1). The concentration of Aroclor 1254 exceeded the background concentration and the RBSLs based on cancer risk and noncancer hazard. The RBSL for cancer risk was based on the cancer slope factor for polychlorinated biphenyls (PCBs).

² Based on the following assumptions: soil ingestion rate, 200 mg/day; drinking water ingestion rate, 2 L/day; 70 kg body weight for typical receptor; maximum soil concentration of 2-methylnaphthalene, 2.58 mg/kg.

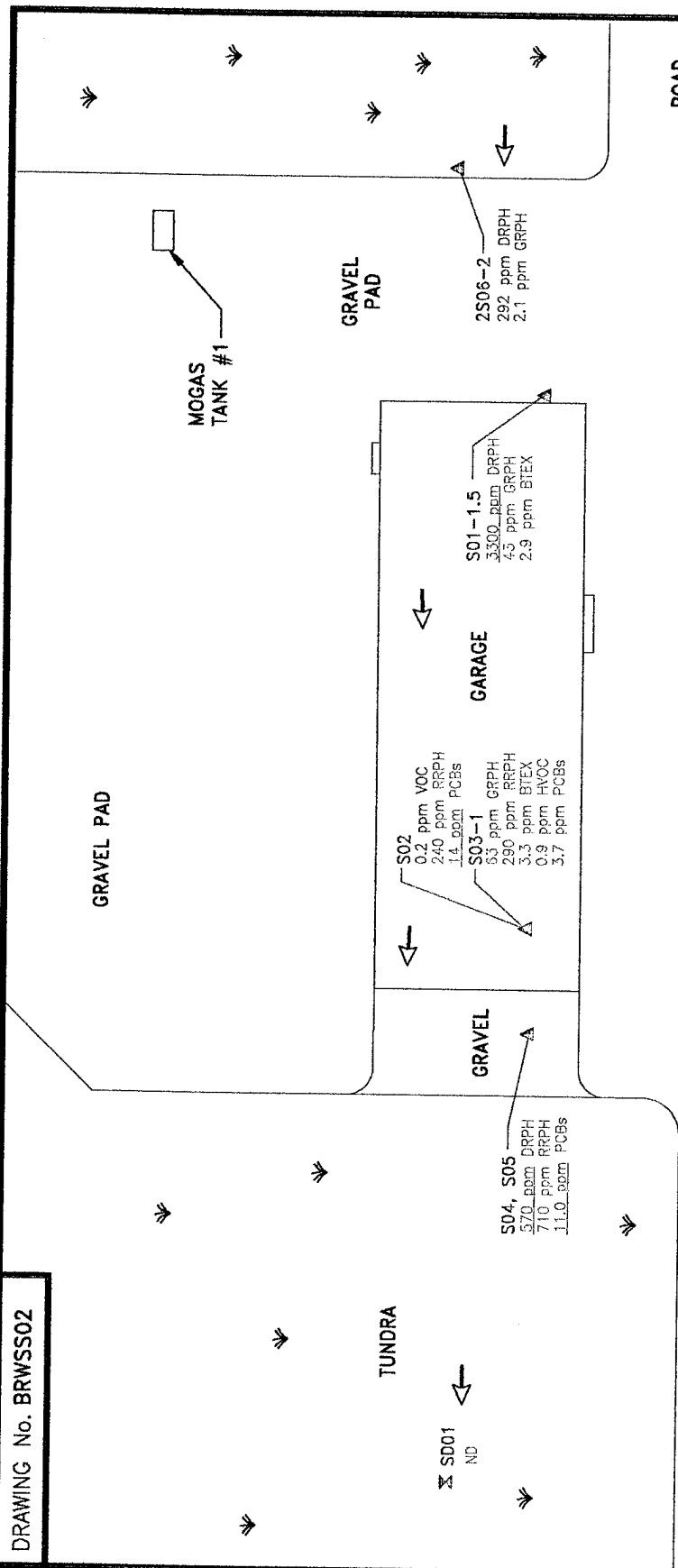
TABLE 2-3. SUMMARY OF THE CHEMICALS OF CONCERN AT POINT BARROW

SITE	CHEMICALS OF CONCERN	
	SOIL/SEDIMENT	SURFACE WATER
Diesel Fuel Spill (SS01)	DRPH GRPH	GRPH Benzene
Garage (SS02)	DRPH GRPH Aroclor 1254	NONE
Air Terminal Area (SS03)	DRPH GRPH Arsenic	GRPH Benzene

* The summary of COCs on this table includes only those chemicals detected that exceed background levels and an RBSL, ARAR, or both. COCs that exceeded background levels but do not have an RBSL or ARAR are discussed in Section 2.1.5 (Page 2-9).

THIS PAGE INTENTIONALLY LEFT BLANK

DRAWING No. BRWSS02

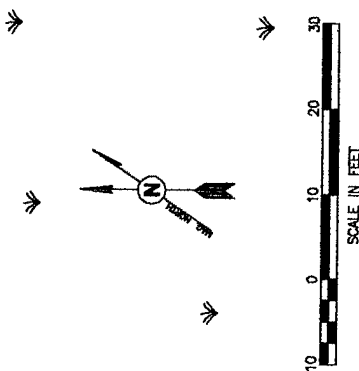


POINT BARROW RADAR INSTALLATION

USAF 611th CES

FIGURE NO. 2-3

GARAGE (S02) SAMPLE LOCATIONS AND ANALYTICAL RESULTS



CONCENTRATIONS ARE ABOVE ACTION LEVELS	
ND	NO CONTAMINATION DETECTED
VOC	TOTAL VOLATILE ORGANIC COMPOUNDS
DRPH	DIESEL RANGE PETROLEUM HYDROCARBONS
GRPH	GASOLINE RANGE PETROLEUM HYDROCARBONS
RRPB	RESIDUAL RANGE PETROLEUM HYDROCARBONS
BTEX	TOTAL BTEX COMPOUNDS
HVOC	TOTAL HALOGENATED VOLATILE ORGANIC COMPOUNDS
PCBs	POLYCHLORINATED BIPHENYLS

LEGEND

	BUILDINGS, STRUCTURES
	ROADS
	SOIL SAMPLE
	SEDIMENT SAMPLE
	TUNDRA
	GRAVEL PAD BOUNDARY
	SURFACE DRAINAGE
	CT&E DATA
	F&B DATA

2.5 ppm
0.9 ppm

THIS PAGE INTENTIONALLY LEFT BLANK

Although it is a member of the PCB family, Aroclor 1254 has not been assigned to an EPA carcinogen weight-of-evidence group.

No surface water bodies were identified at the Garage; therefore, no surface water COCs were identified (Figure 2-3).

2.1.5.3 Air Terminal Area (SS03). DRPH, GRPH, and arsenic were identified as COCs for the soil matrix at the Air Terminal Area (Figure 2-4). The maximum concentrations of DRPH and GRPH exceeded their background concentrations and the ARAR concentrations for petroleum hydrocarbon contamination of soil (ADEC 1991) (Table 2-1). The maximum concentration of arsenic exceeded the background concentration and the RBSLs based on cancer risk and noncancer hazard (Table 2-1). GRPH and benzene were identified as COCs for the surface water matrix at the Air Terminal Area (Figure 2-4). The maximum concentrations of GRPH and benzene exceeded their background concentrations and RBSLs based on cancer. In addition, GRPH exceeded the RBSL based on noncancer and benzene exceeded the ARAR which is an MCL promulgated under the federal Safe Drinking Water Act (Table 2-1).

2.1.5.4 Summary of Chemicals of Concern. The assessment of human health risk at the Point Barrow radar installation is based on the COCs identified in this section. A summary of the COCs is presented in Table 2-3.

2.2 EXPOSURE ASSESSMENT

The exposure assessment section of a baseline human health risk assessment identifies and describes potential receptors and the exposure pathways by which exposure may occur, and estimates the magnitude of those exposures. This section includes an analysis of which pathways are complete (Section 2.2.1), migration and fate of COCs (Section 2.2.2), an estimation of the total intake of the chemicals (Section 2.2.3), and a summary of how the average daily dose (ADD) was calculated (Section 2.2.4).

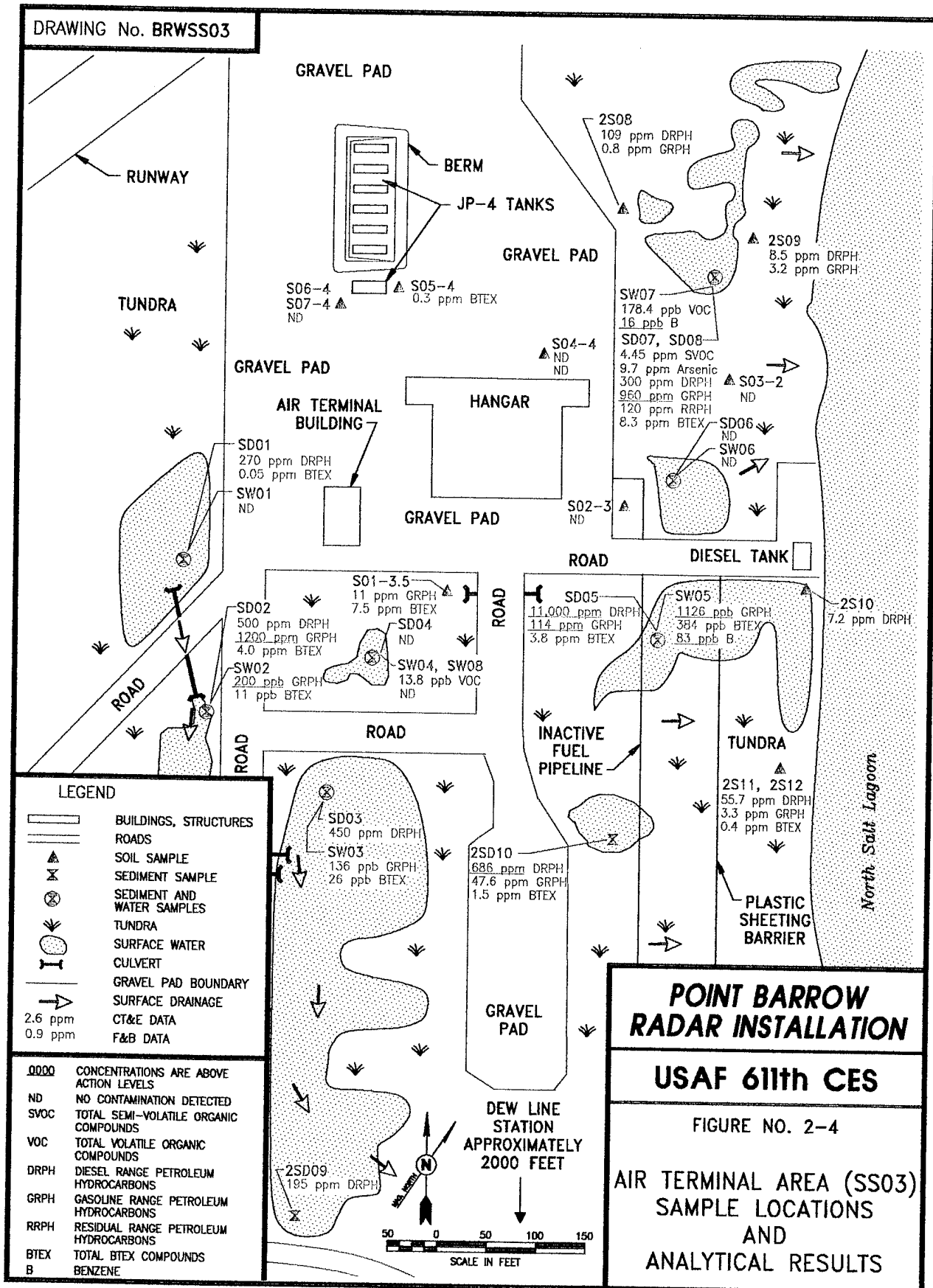
2.2.1 Pathway Analysis

Pathway analysis involves the evaluation of the components of potential exposure pathways and a determination of whether each pathway is complete. An exposure pathway describes the course a chemical will take from a source to an exposure point where a receptor can come into contact with the chemical. A complete exposure pathway has five components:

- source of contamination;
- release mechanism;
- transport mechanism;
- exposure point; and
- receptor.

THIS PAGE INTENTIONALLY LEFT BLANK

DRAWING No. BRWSS03



THIS PAGE INTENTIONALLY LEFT BLANK

If one component of an exposure pathway does not exist, then exposure will not occur and there is no health risk. For example, if a shallow aquifer was contaminated with tetrachloroethene, but that aquifer was not used as a water supply, no exposure point would exist, and a ground water ingestion pathway would not be complete.

The potential exposure pathways evaluated for the Point Barrow human health risk assessment are presented in Figure 2-5 and Table 2-4, and are discussed in Sections 2.2.1.1 through 2.2.1.4.

2.2.1.1 Soil and Sediment Ingestion. Point Barrow installation workers and residents of the city of Barrow may be exposed to soil and sediment contaminated by previous operations at the installation. The most likely exposure routes are incidental ingestion of soil and dermal absorption of contaminants in the soil. Site-specific characteristics will limit the magnitude, frequency, and duration of exposures to soil and sediment. The ground is covered with snow and ice, eliminating soil or sediment exposure for approximately nine months of the year. In the summer months when snow cover is generally absent, cool temperatures (30°F to 46°F) (University of Alaska 1978) keep both workers and villagers in heavy, long-sleeved clothing and gloves that eliminate dermal contact with, and hand-to-mouth transfer of, soil. Therefore, although both the incidental soil ingestion and dermal contact pathways are unlikely to be complete, the incidental ingestion of soil or sediment will be evaluated further in this risk assessment in order to provide cumulative estimates of risk.

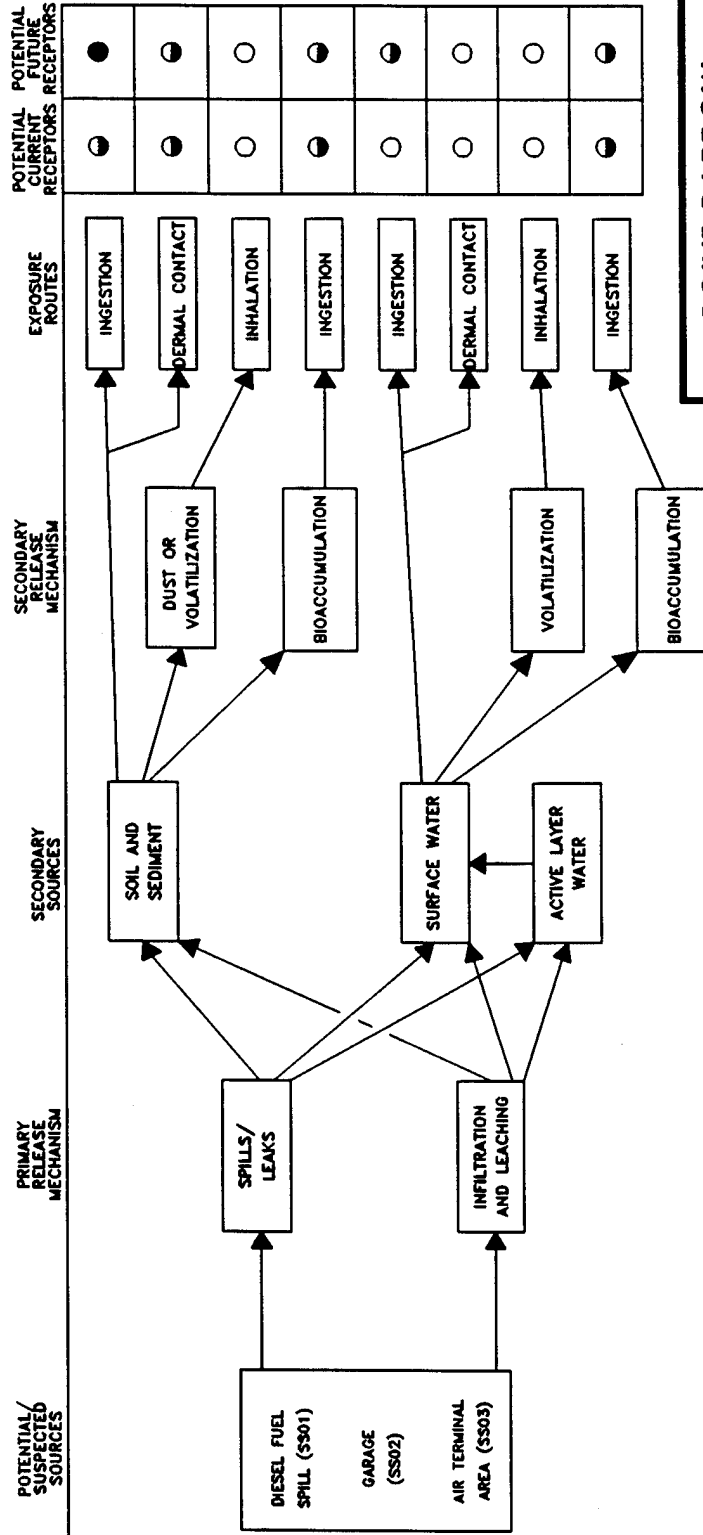
The exposure assumptions used to evaluate the soil and sediment ingestion pathway are upper-bound residential scenario assumptions and, therefore, probably overestimate the true hazard or risk associated with this pathway. The purpose of using residential assumptions is to evaluate the hazard or risk associated with future residential use of the Point Barrow installation. Although the Air Force does not plan to do so, it is possible that the installation may be retired and released for civilian use, in which case residential use of the installation may occur.

2.2.1.2 Inhalation. Point Barrow installation workers and native northerners may be exposed to site contamination by inhalation of organic compounds volatilized from the soil or surface water, or by inhalation of windborne dust to which contamination has adsorbed. These exposure pathways are not considered complete for the Point Barrow risk assessment because snow and ice cover the site for approximately nine months of the year and during the summer months the high humidity, vegetative cover, and thawing of surface and active layer water significantly limit the entrainment of dust particles. The generally low temperatures and high moisture content of the soil also tend to inhibit volatilization. The inhalation pathway will not be considered further in this risk assessment.

2.2.1.3 Water Ingestion. Surface water features, particularly those potentially contaminated by operations at the installation, are not likely to be used for drinking or other domestic purposes even on an incidental basis. This is because these surface water features are frozen for most of the year; therefore, they are not reliable sources of water for domestic or industrial use. However, ingestion of surface water will be considered a potentially complete exposure pathway to reflect the upper-bound potential future risk under a future use scenario. Under current conditions, surface water at the installation is not used for domestic or other purposes. Fresh water for the area is obtained from Katkoak Lagoon located in the middle of

THIS PAGE INTENTIONALLY LEFT BLANK

DRAWING No. BRW-FLOW



- COMPLETE EXPOSURE PATHWAY FOR HUMANS (DEWLINE WORKERS AND NATIVE NORTHERNERS)
- POTENTIALLY COMPLETE PATHWAY
- INCOMPLETE PATHWAY

POINT BARROW
RADAR INSTALLATION

USAF 611th CES

FIGURE NO. 2-5

HUMAN HEALTH
RISK ASSESSMENT
POTENTIAL EXPOSURE
PATHWAYS

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE 2-4. EXPOSURE PATHWAY ANALYSIS FOR POINT BARROW HUMAN HEALTH RISK ASSESSMENT

POTENTIALLY CONTAMINATED MEDIUM	POTENTIAL ROUTES OF EXPOSURE	POTENTIAL RECEPTORS	PATHWAY COMPLETE?	EXPOSED POPULATION ESTIMATE
Soil	Ingestion, dermal absorption	DEW Line workers, Point Barrow residents	Ingestion, Yes Dermal Contact, No	4,000 ^a
Sediment	Ingestion, dermal absorption	DEW Line workers, Point Barrow residents	Ingestion, Yes Dermal Contact, No	4,000 ^a
Air	Inhalation of volatiles from soil or surface water or inhalation of fugitive dust	DEW Line workers, Point Barrow residents	No, volatile concentrations in soil and surface water are very low; dust generation is not likely because of marshy vegetated landscape and high humidity; and snow and ice cover most of the year.	0
Surface Water	Incidental ingestion, dermal absorption	DEW Line workers, Point Barrow residents	Maybe, drinking water supplies are either upgradient from installation or in unaffected areas. Although unlikely, surface water could be used under a hypothetical future use scenario. Fishing occurs in unaffected areas. Swimming does not occur on-site, however, incidental exposure may occur during installation operations or trespassing by native villagers.	4,000 ^a
Ground Water	Ingestion, dermal absorption	DEW Line workers, Point Barrow residents	No, permafrost limits presence of ground water to shallow active layer that is not used for any purpose.	0

^a Estimate based on population data reported in Harcharek (1994).

the city of Barrow. Water from the lagoon is collected from an infiltration gallery and pumped to a water treatment plant. Following treatment, the water is ready for domestic or commercial use and is distributed to homes and businesses by pipeline or haul truck (Hansen 1995). The lagoon is unaffected by contamination from the installation.

2.2.1.4 Ground Water. Permafrost limits the presence of ground water to the active layer, which thaws during the summer months. The water present in the active layer is not known to be used for any purpose; therefore, the ground water pathway will be eliminated from consideration in this risk assessment.

2.2.2 Migration and Fate of Chemicals of Concern

The COCs selected for Point Barrow generally fall into four classes:

- Refined and residual petroleum hydrocarbons (DRPH and GRPH);
- Volatile organic compounds (VOCs: benzene);
- Polychlorinated biphenols (PCBs: Aroclor 1254); and
- Metals (arsenic).

This section presents a summary of the migration and fate of each of these classes given the environmental conditions at Point Barrow.

Once released to the environment, the COCs are immediately subject to several processes, including evaporation and volatilization, bulk flow, soil adsorption, dissolution in surface or active layer water, biodegradation, and photooxidation. The extent to which the COCs undergo each of these processes depends on their chemical and physical properties (e.g., K_{oc} , K_{ow} , water solubility, vapor pressure, Henry's law constant), the volume released, soil flora, meteorological conditions, soil moisture, and organic carbon content.

The migration of petroleum hydrocarbons released to the gravel pads and tundra is expected to follow the rank order: GRPH > DRPH > RRPH. GRPH is generally considered to include hydrocarbons with carbon chain ranges from C5 to C12 that tend to be relatively mobile and less persistent than longer chain hydrocarbons. Depending on the length of time since a spill or leak occurred, the petroleum hydrocarbons observed in soil samples would be expected to be enriched in components that have carbon chain ranges greater than C10 or C11, have high K_{oc} and K_{ow} values, low vapor pressure and water solubility, and are not rapidly biodegradable. Petroleum components that fit this profile are higher molecular weight n-alkanes, mono- and poly-aromatics, and cycloalkanes. These components would tend to appear in laboratory analyses as diesel range or heavy oil range organics (DRPH and RRPH).

The migration of benzene is expected to be rapid compared to the petroleum hydrocarbons. VOCs tend to have high vapor pressures which favor volatilization, high water solubility, and low K_{oc} and K_{ow} values. Therefore, benzene would tend to be highly mobile in the environment and dissipate rapidly after a spill or leak. In the results of field sampling, benzene concentrations would be expected to be fairly low depending on the time since the spill or leak occurred. The

frigid conditions on the North Slope, however, would tend to reduce the mobility due to volatilization or evaporation.

Polychlorinated biphenyls (PCBs), such as Aroclor 1254, are oily substances which would be expected to persist in the environment. In comparison to VOCs (e.g., benzene, tetrachloroethene, and vinyl chloride) which tend to be highly mobile and not persistent in the environment, PCBs have high K_{ow} and K_{oc} values, and low vapor pressure and water solubility values.

The metals observed at Point Barrow are probably of natural origin and not due to the operation of, or activities at, the radar installation; the concentration of arsenic in the soil at the Air Terminal Area (9.7 mg/kg) is within the range of concentrations that would be expected in soil under natural conditions (1 to 50 mg/kg) (Lindsay 1979). Metals in general will tend to be persistent and of low mobility in the environment.

In conclusion, the COCs observed at the Point Barrow installation are generally expected to be fairly persistent and of low mobility. Exposure by contact with soils, primarily through incidental ingestion, is expected to predominate compared to exposure by inhalation.

2.2.3 Estimation of Chemical Intake

The exposure assessment for the Point Barrow DEW Line installation required the development of site-specific assumptions because of the unique location on the North Slope of Alaska. This section of the report focuses on the exposure variables for which site-specific assumptions were made. These variables include:

- exposure frequency;
- exposure duration;
- ingestion of locally produced meat (e.g., caribou, fish, and birds);
- ingestion of locally produced vegetation (e.g., berries);
- soil ingestion rate; and
- rate of dermal contact with soil.

The exposure assumptions used in the human health risk assessment are presented in Table 2-5.

Three potential receptor groups will be evaluated for the Point Barrow risk assessment: an adult assigned to work at the Point Barrow installation (DEW Line worker), an adult native of the North Slope of Alaska (native), and a native child (child). The native adult and child are considered to represent the reasonable maximum exposure that might occur at the installation. Because the Point Barrow installation is close to the city of Barrow and may be released for civilian use in the future, a child will be considered as a potentially exposed individual.

The estimation of chemical intake requires the evaluation of several exposure variables: exposure point concentration; exposure frequency; exposure duration; ingestion of locally produced meat, fish, and vegetation; soil ingestion; drinking water ingestion; dermal contact with soil; and body weight. These exposure variables are discussed in the following sections.

TABLE 2-5. EXPOSURE ASSUMPTIONS FOR ESTIMATING CHEMICAL INTAKE

PARAMETER	DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN CHILD
Exposure Frequency - Soil Ingestion (days/year)	30	30	30
Exposure Frequency - Water Ingestion (days/year)	180	180	N/A
Exposure Duration (years)	10	55 ^a	6 ^a
Soil Ingestion Rate (mg/day)	50	100	200
Drinking Water Ingestion Rate (L/day)	2	2	N/A
Average Body Weight (kg)	70	70	15
Averaging Time (days)	25,550 (cancer) ^b 3,650 (noncancer) ^{c,d}	25,550 ^b (cancer) 20,075 ^c (noncancer) 17,885 ^d (noncancer)	2,190 ^d (noncancer)

N/A Not applicable; drinking water pathway evaluated for adult only.

^a Exposure duration for water ingestion pathway is 55 years (future use scenario). For soil ingestion, exposure duration is six years as a child and 49 years as an adult.

^b Averaging time for the evaluation of cancer risk by the soil and water ingestion pathways.

^c Averaging time for the evaluation of noncancer hazard by the water ingestion pathway.

^d Averaging time for the evaluation of noncancer hazard by the soil ingestion pathway.

2.2.3.1 Exposure Point Concentration. Based on the amount of analytical data available for the risk assessment of the Point Barrow installation, and the requirement that the risk characterization be conducted individually for each of the three sites, only maximum concentrations of the COCs were used for exposure point concentrations. This approach yields a conservative upper-bound estimate of the average daily dose (ADD) for potential receptors.

2.2.3.2 Exposure Frequency. The exposure frequency variable is an estimate of the amount of time a potential receptor may contact contaminated media. For the DEW Line worker, the exposure frequency estimate is based on a duty rotation of eleven months on-site, one month off-site. These estimates are based on knowledge of the site worker's daily activities and vacation allowance. During the eleven months of on-site duty, it is estimated that the worker is outside for four hours per day. The remaining 20 hours is spent inside the module trains or enclosed vehicles, where exposure to contaminated media is not expected to occur.

An estimated exposure frequency for the DEW Line worker is, therefore, 11 months/year x 30 days/month x 4 hours/day x 1 day/24 hours = 55 days/year. The primary environmental medium of concern is, however, contaminated soil, and this estimate of exposure frequency does not account for the number of days per year that snow covers the ground and eliminates the potential for contact with contaminated soil. Six months is a conservative average estimate of the number of months per year of snow cover at arctic DEW Line installations. To be even more conservative, it is assumed that a worker's tour of duty includes all six of the months without

snow cover, thus a soil ingestion exposure frequency of 30 days/year for the DEW Line worker is recommended.

The soil ingestion exposure frequency estimate for a native adult or child of the North Slope is based on an estimate of the frequency with which the individual would be at a DEW Line installation involved in activities that include exposure to soil. Such visits are likely to occur at installations sited near a city like Barrow. In this case, a conservative estimate of exposure would be 4 hrs/day x 30 days per month x 1 day/24 hrs x 6 months of exposed soil = 30 days per year.

The exposure frequency for surface water ingestion was conservatively estimated to be the 180 days/year that surface water would be available (i.e., not frozen), and is based on a potential future scenario where site surface water is used as a sole-source drinking water supply.

2.2.3.3 Exposure Duration. The exposure duration variable is an estimate of the amount of time a potential receptor will remain at or near a DEW Line installation over a lifetime. For the DEW Line worker the exposure duration is an estimate of the maximum tour of duty at an installation. A conservative estimate of the duration of a tour at a particular installation is 10 years based on conversations with DEW Line workers. For the potential native receptor, a conservative estimate of exposure duration is 55 years. EPA's default reasonable maximum exposure duration is 30 years; however, this is based on the overall U.S. population. Because the Alaskan natives are more likely to remain in their village for a longer period, 55 years was determined to be a more appropriate estimate based on best professional judgement.

2.2.3.4 Averaging Time. The averaging time represents the period of time over which exposure is averaged and is based on the assumption that intermittent exposure at a given contaminant concentration is equivalent to a continuous exposure at a lower concentration. For the DEW Line worker, the averaging time is based on the EPA default lifetime of 70 years for evaluation of carcinogens, and 10 years (equivalent to the exposure duration) for the evaluation of noncarcinogens. For the native northern adult an averaging time of 70 years for carcinogens was also chosen. To evaluate exposure to noncarcinogens in soil and sediment for the native northern adult and child, an averaging time of 49 years as an adult and six years as a child was used (to account for a 55 year total exposure). To evaluate the exposure of native northern receptors to noncarcinogens in water an averaging time of 55 years was used.

2.2.3.5 Ingestion of Locally Produced Meat, Fish, and Vegetation. The food supplies of DEW Line installation workers are largely imported from outside the area. Occasionally, a worker would be expected to ingest a locally caught fish or game animal, but the frequency and magnitude of this ingestion is expected to have a negligible effect on exposure to the COCs. Food supplies for the residents of Barrow are largely imported from outside the area, and some reports indicate that the reliance on hunting and fishing for subsistence is decreasing substantially as the economy moves from subsistence to wage labor (Chance 1990). Although Inupiat in general have less time to hunt and fish than in the past, up to 50 percent of their food may derive from subsistence activities (Harcharek 1994). Most of the hunting and fishing that is done occurs outside the city and away from the Point Barrow DEW Line installation in areas unaffected by the installation. It is not likely that contamination observed at the installation has affected the mammals, birds, and vegetation that may be collected for consumption. Therefore,

the consumption of locally produced food is unlikely to pose a significant risk of adverse health effects and will not be considered a complete exposure pathway. The ERA, Section 3, presents a detailed assessment of risks to ecological receptors.

2.2.3.6 Soil Ingestion Rate. A conservative approach to estimating soil ingestion rates is to assume the EPA default soil ingestion rates of 50 mg/day for workers (EPA 1991a) and 100 mg/day for adults in a residential setting (EPA 1989a). The EPA default soil ingestion rate for children is 200 mg/day (EPA 1989a, 1991a); this is the recommended value for the risk assessment.

2.2.3.7 Drinking Water Ingestion Rate. There are no circumstances at the Barter Island installation that would invalidate the EPA default adult drinking water ingestion rate of 2 L/day. Therefore, this is the recommended value for both workers and natives. However, in most, if not all, cases drinking water is imported from offsite so this may not be a route of potential exposure.

By convention (EPA 1989a), noncancer hazard and cancer risk associated with the drinking water pathway are evaluated for an adult receptor, not a child (Table 2-5). The basis for this approach is that the ratio of drinking water ingestion rate to body weight is assumed to remain relatively constant from childhood to adulthood.

2.2.3.8 Dermal Contact with Soil Rate. Because of the harsh North Slope weather, potential receptors (both workers and natives) are expected to be heavily clothed and gloved. Observations made by RI field personnel indicate that potential human receptors were heavily clothed during the months of the field investigation (August and September 1993). Therefore, dermal exposure to contaminated soils is considered negligible. In addition, the duties of installation workers that involve soil work (excavating, grading, etc.) are conducted in equipment with enclosed cabs. Thus, a dermal contact rate does not appear to be necessary for the exposure assessment.

2.2.3.9 Inhalation Rate. The inhalation pathway is not complete (Section 2.2.1.2), so no estimate for this variable is necessary.

2.2.3.10 Body Weight. There are no circumstances at the Point Barrow installation that would invalidate the EPA default adult body weight of 70 kg. Therefore, this is the recommended value for both workers and natives. The recommended body weight for children is the EPA default value of 15 kg.

2.2.4 Quantifying Exposure

For each complete, or potentially complete, exposure pathway at the Point Barrow installation (soil and drinking water ingestion), the ADD for estimating noncancer hazard and the lifetime average daily dose (LADD) for estimating excess lifetime cancer risk were calculated. The equations used for the calculation of ADD and LADD are presented in Table 2-6.

TABLE 2-6. EQUATIONS USED FOR ESTIMATING POTENTIAL DOSE

EXPOSURE ROUTE	EQUATION	PARAMETER DEFINITIONS
Ingestion of Soil	<p>Native Northern Adults/Children</p> $ADD \text{ or } LADD \text{ (mg/kg/day)} = \frac{C_s * CF * EF}{AT} \sum_{i=1}^n \frac{IR_i * ED_i}{BW_i}$	<p>= concentration in soil (mg/kg)</p> <p>= conversion factor (10^{-6} kg/mg)</p> <p>= ingestion rate (mg/day)</p> <p>= exposure frequency (days/year)</p> <p>= exposure duration (years)</p> <p>= body weight (kg)</p> <p>= averaging time (days/year x years)</p>
	<p>DEW Line workers:</p> $ADD \text{ or } LADD \text{ (mg/kg/day)} = \frac{C_s * CF * IR * EF * ED}{BW * AT}$	
Ingestion of Surface Water	$ADD \text{ or } LADD \text{ (mg/kg/day)} = \frac{C_w * CF * IR * EF * ED}{BW * AT}$	<p>= concentration in surface water (µg/L)</p> <p>= conversion fraction (10^{-3} mg/µg)</p> <p>= ingestion rate (L/day)</p> <p>= exposure frequency (days/year)</p> <p>= exposure duration (years)</p> <p>= body weight (kg)</p> <p>= averaging time (days/year x years)</p>

The exposure assumptions assigned to each variable in these equations are presented in Table 2-5. The estimates of ADD and LADD for the COCs at each site are presented in the risk characterization spreadsheets in Appendix A.

2.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood or severity of adverse effects or both. This is done separately for noncarcinogenic effects (Section 2.3.1) and carcinogenic effects (Section 2.3.2). Toxicity summaries are presented in Section 2.3.3.

Toxicity assessment for environmental contaminants generally is accomplished in two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining whether exposure to an agent can cause an increase in the incidence of a particular adverse health effect (e.g., cancer, birth defects) and whether the adverse health effect is likely to occur in humans. Hazard identification involves characterizing the nature and strength of the evidence of causation. Dose-response evaluation is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population. From this quantitative dose-response relationship, toxicity values (e.g., reference doses and slope factors) are derived that can be used to estimate the incidence or potential for adverse effects as a function of human exposure to the agent. These toxicity values are used in the risk characterization step to estimate the likelihood of adverse effects occurring in humans at particular exposure levels.

2.3.1 Toxicity Assessment for Noncarcinogenic Effects

A reference dose, or RfD, is the toxicity value used most often in evaluating noncarcinogenic effects resulting from exposures at contaminated sites. Various types of RfDs are available depending on the exposure route (oral or inhalation), the critical effect (developmental or other), and the length of exposure being evaluated (chronic, subchronic, or single event). The oral RfDs used to estimate the noncancer hazard associated with exposure to soils, sediments, and surface water at the Point Barrow installation are presented in Table 2-7.

A chronic RfD is defined as an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs are developed specifically to be protective for long-term exposure to a compound. Chronic RfDs generally should be used to evaluate the potential noncancerous effects associated with exposure periods between seven years (approximately 10 percent of a human lifetime) and a lifetime. Many chronic RfDs have been reviewed and verified by the intra-agency RfD Workgroup and entered into EPA's IRIS database.

TABLE 2-7. TOXICITY CRITERIA FOR NONCANCER EFFECTS OF THE CHEMICALS OF CONCERN FOR POINT BARROW

CHEMICAL	ORAL REFERENCE DOSE (RfD) (mg/kg-day)	TARGET ORGAN OR CRITICAL EFFECT (species) ^a	UNCERTAINTY FACTOR ^b	ORAL RfD SOURCE ^c
Aroclor 1254	0.00002	ocular exudate, inflamed Meibomian glands, distorted nail growth, immunosuppression (monkey)	300	IRIS
Arsenic	0.0003	hyperpigmentation, keratosis, and possible vascular complications (human)	3	IRIS
Benzene	NA	NA	NA	NA
DRPH	0.08 ^d	liver effects (mice)	10,000	ECAO
GRPH	0.2 ^d	decreased body weight (rats)	1000	ECAO

^a A target organ is the organ apparently most sensitive to the toxicity of a chemical. A critical effect is reported when EPA has not identified a target organ for the toxicity of a given chemical.

^b The uncertainty factors used to develop oral reference doses are generally applied in multiples of 10 to account for shortcomings in the toxicological database. The greater the uncertainty factor, the lower the confidence level placed on that RfD. Factors of 10 are applied to account for human variability in toxic response, extrapolation from animal studies to humans, extrapolation of short-term exposures to long-term exposures, and the extrapolation of a lowest-observed adverse effect level (LOAEL) to a no observed adverse effect level (NOAEL).

^c Sources of oral RfD values are IRIS (Integrated Risk Information System) or ECAO (The Environmental Criteria and Assessment Office of EPA).

^d Oral RfD values for DRPH, GRPH, and RRPH are based on (EPA 1992b) and are considered provisional.

NA Not available.

2.3.1.1 Concept of Threshold. To limit noncancerous effects, humans and other animals have protective mechanisms that must be overcome before an adverse effect is manifested. For example, where a large number of cells perform the same or similar function, the cell population may have to be significantly depleted before the adverse effect is seen. As a result, a range of exposures from zero to some finite level exists that can be tolerated by the organism with essentially no chance of expression of adverse effects. In developing a toxicity value for evaluating noncancerous effects (i.e., an RfD), the approach is to identify the upper bound of this tolerance range (i.e., the maximum subthreshold level). Because variability exists among humans, attempts are made to identify a subthreshold level that protects sensitive individuals in the population. For most chemicals, this level can only be estimated; the RfD incorporates uncertainty factors indicating the degree of extrapolation used to derive the estimated value. RfD summaries in IRIS also contain a statement expressing the overall confidence that the evaluators have in the RfD (high, medium, or low). The RfD is generally considered to have uncertainty spanning an order of magnitude or more, so the RfD should not be viewed as a strict scientific demarcation between levels that are toxic and nontoxic.

2.3.2 Toxicity Assessment For Carcinogenic Effects

A slope factor and the accompanying weight-of-evidence determination are the toxicity data most commonly used to evaluate potential human carcinogenic risks. The methods EPA uses to derive these values are outlined below. Additional information can be obtained by consulting EPA's *Guidelines for Carcinogen Risk Assessment* (EPA 1986a) and IRIS Background Document #2 (IRIS 1995). The slope factors for the COCs at Point Barrow are presented in Table 2-8.

2.3.2.1 Concept of Nonthreshold Effects. Risk evaluation based on the presumption of a dose-response threshold is generally thought to be inappropriate for carcinogenesis. In the evaluation of carcinogens, EPA assumes that a small number of molecular events can evoke changes in a single cell and lead to uncontrolled cellular proliferation and eventually to clinical state of disease (cancer). This hypothesized mechanism for carcinogenesis is referred to as "nonthreshold" because all levels of exposure pose some probability of generating a carcinogenic response. Thus, no dose is thought to be risk-free, and an effect threshold cannot be estimated.

For carcinogens, EPA uses a two-part evaluation in which the substance first is assigned a weight-of-evidence classification, and a slope factor is calculated.

2.3.2.2 Assigning a Weight-of-Evidence. In the first step of the evaluation, the carcinogenicity data are evaluated to determine the likelihood that the agent is a human carcinogen. The evidence is characterized separately for human studies and animal studies as sufficient, limited, inadequate, no data, or evidence of no effect. The characterizations of these two types of data are combined and based on the extent to which the agent has been shown to be a carcinogen in experimental animals, humans, or both, the agent is given a provisional weight-of-evidence classification. EPA scientists then adjust the provisional classification upward or downward based on other supporting evidence of carcinogenicity.

The EPA classification system for weight-of-evidence is shown in Table 2-9.

TABLE 2-8. TOXICITY VALUES FOR THE CARCINOGENICITY OF THE CHEMICALS OF CONCERN AT POINT BARROW

CHEMICAL	WEIGHT-OF-EVIDENCE (WOE)	TUMOR TYPE (species)	ORAL SLOPE FACTOR (kg-day/mg)	ORAL SLOPE FACTOR SOURCE ^a
Arsenic	A	skin cancer (human)	1.5	IRIS
Benzene	A	leukemia	0.029	IRIS
DRPH	NA	NA	NA	NA
GRPH	C	liver adenoma/carcinoma (mouse)	0.0017	ECAO
PCB (Aroclor 1254)	B2	trabecular carcinoma/adeno-carcinoma, neoplastic nodule (rat)	7.7	IRIS

^a IRIS, Integrated Risk Information System; ECAO, Environmental Criteria and Assessment Office of EPA.
NA Not available.

TABLE 2-9. EPA WEIGHT-OF-EVIDENCE CLASSIFICATION SYSTEM FOR CARCINOGENICITY

GROUP	DESCRIPTION
A	Human carcinogen.
B1 or B2	Probable human carcinogen.
	B1 indicates that limited human data are available.
	B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
C	Possible human carcinogen.
D	Not classifiable as to human carcinogenicity.
E	Evidence of noncarcinogenicity for humans.

2.3.2.3 Generating a Slope Factor. For chemicals classified as known or probable human carcinogens, a toxicity value that defines quantitatively the relationship between dose and response (i.e., the slope factor) is calculated. Slope factors (SFs) typically are calculated for potential carcinogens in classes A, B1, and B2. Quantitative estimation of slope factors for the chemicals in class C is done on a case-by-case basis.

Generally, the slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used in risk assessments to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. Slope factors should always be accompanied by the weight-of-evidence classification to indicate the strength of the evidence that the agent is a human carcinogen.

2.3.2.4 Identifying the Appropriate Data Set. In deriving slope factors, the available information about a chemical is evaluated, and an appropriate data set is selected; human data of high quality are preferable to animal data. If animal data are used, the species that responds most similarly to humans (with respect to factors such as metabolism, physiology, and pharmacokinetics) is preferred. When no clear choice is possible, the most sensitive species is given the greatest emphasis. Occasionally, in situations where no single study is judged most appropriate yet several studies collectively support the estimate, the geometric mean of estimates from all studies may be adopted as the slope factor. This practice ensures the inclusion of all relevant data.

2.3.2.5 Extrapolating to Lower Doses. Because risk at low exposure levels is difficult to measure directly either by animal experiments or by epidemiologic studies, the development of a slope factor generally entails applying a model to the available data set and using the model to extrapolate from the relatively high doses administered to experimental animals (or the

exposures noted in epidemiologic studies) to the lower exposure levels expected for human contact in the environment.

A number of mathematical models and procedures have been developed to extrapolate from carcinogenic responses observed at high doses to responses expected at low doses. Different extrapolation methods may provide a reasonable fit to the observed data but may lead to large differences in the projected risk at low dose.

In general, after the data are fit to the appropriate model, the upper 95th percent confidence limit of the slope of the resulting dose-response curve is calculated. This value is known as the slope factor and represents an upper 95th percent confidence limit on the probability of a response per unit intake of a chemical over a lifetime (i.e., there is only a five percent chance that the probability of a response could be greater than the estimated value on the basis of the experimental data and model used). In some cases, slope factors based on human dose-response data are based on the "best" estimate instead of the upper 95th percent confidence limits. Because the dose-response curve generally is linear only in the low-dose region, the slope factor estimate only holds true for low doses. Information concerning the limitations on use of slope factors can be found in IRIS.

2.3.2.6 Summary of Dose-Response Parameters. Toxicity values for carcinogenic effects can be expressed in several ways. The slope factor is generally considered to be the upper 95th percent confidence limit of the slope of the dose-response curve and is expressed as (mg/kg-day)⁻¹. Thus:

$$\begin{aligned}\text{Slope factor} &= \text{risk per unit dose} \\ &= \text{risk per mg/kg-day}\end{aligned}$$

Where data permit, slope factors listed in IRIS are based on absorbed doses, although many of them have been based on administered doses.

2.3.3 Summaries of the Toxicity of the Chemicals of Concern

Tables 2-7 and 2-8 present chronic cancer and noncancer health effects criteria (oral slope factors and RfDs, respectively) for the COCs. The toxicological properties of the COCs and the toxicological basis of the health effects criteria listed in Tables 2-7 and 2-8 are discussed in Appendix B.

2.4 RISK CHARACTERIZATION

In the risk characterization, the toxicity and exposure assessments are summarized and integrated into quantitative and qualitative expressions of risk. To characterize potential noncancerous effects, comparisons are made between projected intakes (ADD) of substances and toxicity values (e.g., the reference dose). To characterize potential carcinogenic effects, probabilities that an individual will develop cancer over a lifetime of exposure are estimated from projected intakes (LADD) and chemical-specific dose-response information (e.g., the slope factor).

Major assumptions, scientific judgements and to the extent possible, estimates of the uncertainties embodied in the assessment are also presented. In this section methods of quantifying risks are discussed and applied to individual sites on the Point Barrow installation.

2.4.1 Quantifying Risks

This section describes steps for quantifying risk or hazard indices for both carcinogenic and noncancerous effects to be applied to each exposure pathway analyzed. The first two subsections cover procedures for individual substances and are followed by a subsection on procedures for quantifying risks associated with simultaneous exposures to several substances.

2.4.1.1 Risks from Individual Substances - Carcinogenic Effects. For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen (i.e., incremental or excess individual lifetime cancer risk). The guidelines provided in this section are consistent with EPA (1986a). For some carcinogens, there may be sufficient information on mechanism of action that a modification of the approach outlined below is warranted. Alternative approaches may be considered in consultation with ECAO on a case-by-case basis.

The SF converts estimated daily intakes averaged over a lifetime of exposure directly to incremental risk of an individual developing cancer. Because environmental exposure is likely to result in relatively low intakes (compared to those experienced by test animals), it generally can be assumed that the dose-response relationship will be linear in the low-dose portion of the multistage model dose-response curve. Under this assumption the slope factor is a constant, and risk will be directly related to intake. Thus, the linear form of the carcinogenic risk equation is usually applicable for estimating cancer risks. This linear low-dose equation is described below.

LINEAR LOW-DOSE CANCER RISK EQUATION

$$\text{Risk} = \text{LADD} \times \text{SF}$$

where:

Risk =	a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer;
LADD =	lifetime average daily dose averaged over 70 years (mg/kg-day); and
SF =	slope factor, expressed in (mg/kg-day) ⁻¹

Because the slope factor is often an upper 95th percentile confidence limit of the probability of response based on experimental animal data used in the multistage model, the carcinogenic risk estimate generally will be an upper-bound estimate. This means that the "true risk" will probably not exceed the risk estimate derived through use of this model and is likely to be lower than predicted.

2.4.1.2 Noncancer Hazards from Individual Substances - Noncancerous Effects. The measure used to describe the potential for noncancerous toxicity in an individual is not expressed as the probability of an individual suffering an adverse effect. EPA does not at the present time use a probabilistic approach to estimate the potential for noncancerous health effects. Instead, the potential for noncancerous effects is evaluated by comparing an exposure

level over a specified time period (e.g., some fraction of a lifetime) with an RfD derived for a similar exposure period. This ratio of exposure to toxicity is called a hazard quotient (HQ).

The noncancer HQ assumes there is a level of exposure (i.e., the RfD) below which it is unlikely even for sensitive populations to experience adverse health effects. If the exposure level (ADD) exceeds this threshold (i.e., if ADD/RfD exceeds unity), there may be concern for potential noncancer effects. As a rule, the greater the value of ADD/RfD above unity, the greater the level of concern. Ratios of ADD/RfD should not be interpreted as statistical probabilities; a ratio of 0.001 does not mean that there is a one in one thousand chance of the effect occurring. Further, it is important to emphasize that the level of concern does not increase linearly as the RfD is approached or exceeded because RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects. Thus, the slopes of the dose-response curve in excess of the RfD can range widely depending on the substance.

NONCANCER HAZARD QUOTIENT

$$\text{Noncancer Hazard Quotient} = \text{ADD/RfD}$$

where:

ADD = average daily dose (or intake);

RfD = reference dose

ADD and RfD are expressed in the same units and represent the same exposure period (e.g., chronic, subchronic, or short-term).

2.4.1.3 Aggregate Risks for Multiple Substances. Estimating risk or hazard potential by considering one chemical at a time might significantly underestimate the risks associated with simultaneous exposures to several substances. To assess the overall potential for cancer and noncancer effects posed by multiple chemicals, EPA has developed *Guidelines for the Health Risk Assessment of Chemical Mixtures* (EPA 1986b). These guidelines can be applied to the case of simultaneous exposures to several chemicals from a variety of sources by more than one exposure pathway. Information on specific mixtures is rarely available. Even if such data exist, they are often difficult to use. Monitoring for "mixtures" or modeling the movement of mixtures across space and time present significant technical problems given the likelihood that individual components will behave differently in the environment (i.e., fate and transport).

Although the calculation procedures differ for carcinogenic and noncarcinogenic effects, both sets of procedures assume dose additivity in the absence of information on specific mixtures.

Carcinogenic effects. The cancer risk equation described below is used to estimate the incremental individual lifetime cancer risk for simultaneous exposure to several carcinogens and is based on EPA's risk assessment guidelines. This equation represents an approximation of the precise equation for combining risks that accounts for the joint probabilities of the same individual developing cancer as a consequence of exposure to two or more carcinogens. The difference between the precise equation and the approximation described in the equation below is negligible for total cancer risks less than 0.1. Thus, the simple additive equation is appropriate for most risk assessments.

CANCER RISK EQUATION FOR MULTIPLE SUBSTANCES

$$\text{Risk}_T = \sum \text{Risk}_i$$

where:

Risk_T = the total cancer risk, expressed as a unitless probability; and
 Risk_i = the risk estimate for the i^{th} substance.

The risk summation techniques described in the cancer risk equation above assume that intakes of individual substances are small. They also assume independence of action by the compounds involved (i.e., there are no synergistic or antagonistic chemical interactions and all chemicals produce the same effect, i.e., cancer). If these assumptions are incorrect, over- or under-estimation of the actual multiple-substance risk could result.

A separate total cancer risk for each exposure pathway is calculated by summing the substance-specific cancer risks. Resulting cancer risk estimates should be expressed using one significant figure only.

There are several limitations to this approach. First, because each slope factor is an upper 95th percentile estimate of potency and upper 95th percentiles of probability distributions are not strictly additive, the total cancer risk estimate might artificially become more conservative as risks from a number of different carcinogens are summed. If one or two carcinogens drive the risk, however, this problem is not of concern. Second, it often will be the case that substances with different weights of evidence for human carcinogenicity are included. The cancer risk equation for multiple substances sums all carcinogens equally, giving as much weight to class B or C as to class A carcinogens. In addition, slope factors derived from animal data will be given the same weight as slope factors derived from human data. Finally, the action of two different carcinogens might not be independent.

Noncancerous effects. To assess the overall potential for noncancerous effects posed by more than one chemical, a hazard index approach has been developed based on EPA's *Guidelines for Health Risk Assessment of Chemical Mixtures* (EPA 1986b). This approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures. The hazard index is equal to the sum of the HQs. When the hazard index exceeds unity, there may be concern for potential health effects. Any single chemical with an exposure level greater than the toxicity value will cause the hazard index to exceed unity, and for multiple chemical exposures, the hazard index can exceed unity even if no single chemical exposure exceeds its RfD. The equation used to determine noncancer hazard index is as follows:

NONCANCER HAZARD INDEX

$$\text{Hazard Index} = \text{ADD}_1/\text{RfD}_1 + \text{ADD}_2/\text{RfD}_2 + \dots + \text{ADD}_i/\text{RfD}_i$$

where:

ADD_i = average daily dose (or intake) for the i^{th} toxicant;

RfD_i = reference dose for the i^{th} toxicant; and

ADD and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or shorter-term).

Where appropriate, a separate chronic hazard index can be calculated from the ratios of the chronic daily intake (CDI) to the chronic RfD for individual chemicals as described below.

CHRONIC NONCANCER HAZARD INDEX

$$\text{Chronic Hazard Index} = \text{LADD}_1/\text{RfD}_1 + \text{LADD}_2/\text{RfD}_2 + \dots + \text{LADD}_i/\text{RfD}_i$$

where:

LADD_i = lifetime average daily dose for the i^{th} toxicant in mg/kg-day, and

RfD_i = chronic reference dose for the i^{th} toxicant in mg/kg-day.

There are several limitations to this approach. As mentioned earlier, the level of concern does not increase linearly as the RfD is approached or exceeded because the RfDs do not have equal accuracy or precision and are not based on the same severity of effect. Moreover, HQs are combined for substances with RfDs based on critical effects of varying toxicological significance. It will often be the case that RfDs of varying levels of confidence, including different uncertainty adjustments and modifying factors, will be combined (e.g., extrapolation from animals to humans, from lowest-observed adverse effect levels (LOAELs) to no observed adverse effect levels (NOAELs), or from one exposure duration to another).

Another limitation with the hazard index approach is that the assumption of dose additivity is most properly applied to compounds that induce the same effect by the same mechanism of action. Consequently, application of the hazard index equation to a number of compounds that are not expected to induce the same type of effects or that do not act by the same mechanism could overestimate the potential for effects. Such an approach is, however, appropriate at a screening level. This possibility is generally not of concern if only one or two substances are responsible for driving the hazard index above unity. If the hazard index is greater than unity as a consequence of summing several HQs of similar value, it is appropriate to segregate the compounds by effect and by mechanism of action and derive separate hazard indices for each group.

2.4.2 Site-Specific Risk Characterization

Soil and Sediment Exposures. The quantification of noncancer hazard and excess lifetime cancer risk associated with the soil ingestion pathway at the Point Barrow installation was based on analytical data from soil and sediment samples collected within the interval from ground surface to permafrost. No attempt was made to segregate surface soil samples from subsurface samples in the risk characterization.

The noncancer hazard and excess lifetime cancer risk associated with the ingestion of soil or sediment containing COCs has been estimated for a hypothetical native northerner based on six years of exposure as a child and 49 years of exposure as an adult. For cancer risk, the exposure was averaged over 70 years. For the DEW Line worker, cancer risk has been estimated based on ten years of exposure averaged over a default lifetime of 70 years. Noncancer hazard for the DEW Line worker was based on a 10 year exposure.

Surface Water Exposures. The noncancer hazard and the excess lifetime cancer risk associated with the ingestion of surface water containing COCs has been estimated based on a native northern adult and a DEW Line worker. A native northern child receptor was not considered because, unlike exposure to soil, which is expected to be greater in a child than in an adult, the ratio of drinking water ingestion rate to body weight is assumed to be relatively constant from childhood to adulthood. A greater number of years is spent as an adult, so estimating hazard or risk for water ingestion based on an adult is a more conservative approach. The exposure duration estimate for the DEW Line worker was 10 years and for the native northern adult was 55 years. Exposures were averaged over 10 years for DEW Line worker exposure to noncarcinogens, and 55 years for native northern adult exposure to noncarcinogens. Exposures were averaged over 70 years for both receptor groups to characterize the risk associated with exposure to carcinogens in surface water.

Ingestion of surface water at the Point Barrow installation is not considered to be a complete pathway under a current use scenario. Under a future use scenario, however, it is possible that the buildings could be used for residences or additional residential structures could be erected at the installation. The future residents could be either DEW Line workers or native northerners. The residents of the city of Point Barrow currently receive their domestic water from a fresh water lagoon located in the city. This water is transported by a pipeline to a treatment facility in the city and then distributed by truck. Therefore, because sources of water may change in the future, potential ingestion of surface water at the installation will be evaluated for the DEW Line worker and native northern adult under a future use exposure scenario only.

Table 2-10 contains a site-by-site summary of the COCs in each medium, and the noncancer hazard and excess lifetime cancer risk associated with exposure to the COCs in the soils, sediments, and surface water. Table 2-9 does not include media where no COCs were identified, for example, surface water at the Garage (SS02). COCs without toxicity data (RBSLs or ARARs) are not included on Table 2-10, but are discussed in Section 2.1.5. Appendix A contains the spreadsheets used to calculate the noncancer hazard and excess lifetime cancer risk estimates presented in Table 2-10.

Risk Characterization of Petroleum Hydrocarbons. Petroleum hydrocarbons represent a primary source of contamination at the Point Barrow installation. The laboratory analysis of soil, sediment, and surface water samples revealed the presence of DRPH, GRPH, and RRP. To characterize the risk associated with exposure to these compounds, the provisional RfDs and the slope factor developed by EPA for petroleum hydrocarbons (EPA 1992b) were applied. These provisional RfDs provide the best available tool for characterizing the risk associated with exposure to the petroleum hydrocarbons. The RfD for JP-4 documented by EPA (1992b) was

TABLE 2-10. SUMMARY OF NONCANCER HAZARD AND EXCESS LIFETIME CANCER RISK FOR POINT BARROW

SITE	MEDIUM	NONCARCINOGENIC COCs ^a	NONCANCER HAZARD ^c			CARCINOGENIC COCs ^a	EXCESS LIFETIME CANCER RISK ^d		
			DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD		DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD
Diesel Fuel Spill (SS01)	Soil or Sediment	DRPH GRPH	0.003	NA ^e	0.06	GRPH	3×10^{-9}	NA ^e	6×10^{-8}
	Surface Water	GRPH	0.1	0.1	NA ^f	GRPH Benzene	6×10^{-6}	3×10^{-5}	NA ^f
Garage (SS02)	Soil or Sediment	DRPH GRPH PCBs (Aroclor 1254)	0.04	NA	0.9	GRPH PCBs (Aroclor 1254)	9×10^{-7}	NA	2×10^{-5}
	Surface Water	None ^b	NA	NA	NA	None ^b	NA	NA	NA
Air Terminal Area (SS03)	Soil or Sediment	DRPH GRPH Arsenic	0.01	NA	0.2	GRPH Arsenic	2×10^{-7}	NA	3×10^{-6}
	Surface Water	GRPH	0.08	0.08	NA	GRPH Benzene	9×10^{-6}	6×10^{-5}	NA

^a All COCs are listed together regardless of whether they contribute to the hazard index, cancer risk, or both.

^b None, no COCs selected.

^c Hazard index, noncancer hazard index. The hazard index is the sum of the hazard quotients for all of the COCs associated with a given medium, pathway, and receptor group.

^d Cancer risk, excess lifetime cancer risk. The cancer risk is the sum of the excess lifetime cancer risks for all of the COCs associated with a given medium, pathway, and receptor group.

^e Children are assumed to have a soil ingestion rate greater than that for adults. Therefore, under a residential scenario, the estimates of noncancer hazard and cancer risk associated with soil ingestion are estimated for a combined adult and child receptor only. This estimate is considered a conservative upper bound on the true hazard or risk.

^f Drinking water ingestion, unlike soil ingestion, is evaluated for an adult receptor but not a child receptor because adults are assumed to have a longer exposure duration at a greater water ingestion rate. Therefore, the hazard or risk estimated will represent an upper bound, conservative estimate. For soil ingestion, the child soil ingestion rate is assumed to exceed that for adults. Therefore, a combination of the adult and child receptor groups is used to evaluate soil ingestion risk and hazard. Text indicates exceedance of regulatory benchmarks: $HQ > 1$, Cancer Risk $> 1 \times 10^{-6}$.

BOLD

used to represent DRPH and RRPB, and the RfD and slope factor for unleaded gasoline were used to represent GRPH.

The noncancer hazard associated with exposure to DRPH, GRPH, and RRPB was estimated by dividing the compound- and site-specific ADD by the appropriate provisional RfD (EPA 1992b). The excess lifetime cancer risk associated with exposure to GRPH was estimated by multiplying the compound- and site-specific LADD by the slope factor for unleaded gasoline (EPA 1992b).

Although the provisional RfDs and slope factor represent the best available numerical estimate of toxicity, there is a significant amount of uncertainty associated with their use at the Point Barrow installation. The RfDs and slope factor are based on studies in mice and rats that used inhalation as the route of exposure; however, for this risk assessment, exposure of humans by the ingestion route is being evaluated. Furthermore, in the absence of a more thorough study to compare the DRPH, GRPH, and RRPB to known petroleum refinery streams, it is not clear how well the provisional values represent the toxicity of diesel and gasoline in humans.

Risk Characterization of Chemicals Detected. Chemicals detected above background levels without RBSLs or ARARs are evaluated in Section 2.1.5 (page 2-9). Based on the information in that section, and the relatively low levels detected at the sites, these chemicals are not expected to pose a health risk. Risk characterization of chemicals detected that exceed RBSLs, ARARs, or both are discussed on a site-by-site basis below.

2.4.2.1 Diesel Fuel Spill (SS01).

Soils and Sediments. The noncancer hazard associated with the ingestion of soil at the Diesel Fuel Spill site by a hypothetical native northern adult/child is 0.06, and by a DEW Line worker is 0.003, based on the maximum concentrations of the COCs (Tables 2-10 and A-1). The presence of DRPH and GRPH accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

The excess lifetime cancer risk associated with the ingestion of soil or sediment at the Diesel Fuel Spill site by a hypothetical native northern adult/child is 6×10^{-8} , and by a DEW Line worker is 3×10^{-9} , based on the maximum concentration of the carcinogenic COC (Table A-2). The presence of GRPH accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations.

Surface Water. The noncancer hazard associated with the ingestion of surface water at the Diesel Fuel Spill site by both a hypothetical native northern adult and a DEW Line worker is 0.1, based on the maximum concentration of the COC (Tables 2-10 and A-3). GRPH account entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

The excess lifetime cancer risk associated with the ingestion of surface water at the site by a native northern adult is 3×10^{-5} , and by a DEW Line worker is 6×10^{-6} , based on the maximum concentrations of the COCs (Table A-4). The presence of GRPH and benzene accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations. GRPH alone accounts for 90 percent of the cancer risk.

2.4.2.2 Garage (SS02).

Soils and Sediments. The noncancer hazard associated with the ingestion of soil at the Garage by a hypothetical native northern adult/child is 0.9, and by a DEW Line worker is 0.04, based on the maximum concentrations of the COCs (Tables 2-10 and A-5). The presence of DRPH, GRPH, and Aroclor 1254 accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations. Aroclor 1254 alone accounts for more than 90 percent of the noncancer hazard.

The excess lifetime cancer risk associated with the ingestion of soil or sediment at the site by a hypothetical native northern adult/child is 2×10^{-5} , and by a DEW Line worker is 9×10^{-7} , based on the maximum concentrations of the carcinogenic COCs (Table A-6). The presence of GRPH and Aroclor 1254 accounts entirely for the quantifiable cancer risk for these receptor/pathway combinations. Aroclor 1254 accounts for more than 99 percent of the quantifiable excess lifetime cancer risk.

Surface Water. No surface water bodies were identified at the Garage; therefore, no evaluation of noncancer hazard or excess lifetime cancer risk associated with ingestion of surface water was conducted.

2.4.2.3 Air Terminal Area (SS03).

Soils and Sediments. The noncancer hazard associated with the ingestion of soil at the Air Terminal Area by a hypothetical native northern adult/child is 0.2, and by a DEW Line worker is 0.01, based on the maximum concentrations of the COCs (Tables 2-10 and A-7). The presence of DPRH, GRPH, and arsenic accounts entirely for the quantifiable noncancer hazard for these receptor/pathway combinations. DRPH alone accounts for approximately 80 percent of the noncancer hazard.

The excess lifetime cancer risk associated with the ingestion of soil or sediment at the site by a hypothetical native northern adult/child is 3×10^{-6} , and by a DEW Line worker is 2×10^{-7} , based on the maximum concentration of the carcinogenic COC (Table A-8). The presence of GRPH and arsenic accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations. Arsenic alone accounts for more than 90 percent of the cancer risk.

Surface Water. The noncancer hazard associated with the ingestion of surface water at the Air Terminal Area by a hypothetical native northern adult and by a DEW Line worker is 0.08, based on the maximum concentrations of the COCs (Tables 2-10 and A-9). GRPH account entirely for the quantifiable noncancer hazard for these receptor/pathway combinations.

The excess lifetime cancer risk associated with the ingestion of surface water at the site by native northern adults is 6×10^{-5} , and by a DEW Line worker is 9×10^{-6} , based on the maximum concentrations of the COCs (Table A-10). The presence of GRPH and benzene accounts entirely for the quantifiable excess lifetime cancer risk for these receptor/pathway combinations.

2.5 RISK CHARACTERIZATION UNCERTAINTY

Several sources of uncertainty affect the estimates of excess lifetime cancer risk and noncancer hazard as presented in this risk assessment. The sources are generally associated with:

- Sampling and analysis of soil, sediment, and surface water;
- Assigning the source of contamination;
- Exposure assumptions, including estimates of exposure point concentrations;
- Evaluation of the toxicity of the COCs; and
- Methods and assumptions used to characterize the cancer risk and noncancer hazard.

Uncertainties associated with sampling and analyses include the inherent variability (standard error) in the analyses, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. The quality assurance/quality control program used in conducting the sampling and analyses serves to reduce errors, but it can not eliminate all errors associated with sampling and analyses. There is some uncertainty in the selection of COCs with respect to sample quantitation limits for a given chemical. In some cases a chemical may have had detected values below the COC screening criteria as well as samples with quantitation limits greater than the screening criteria. In these cases it should be understood that only the samples with adequate quantitation limits are applicable to the screening process. Thus, the number of samples used to screen a chemical would be less than the total number of analyses for that chemical.

Simplifying assumptions were made about the environmental fate and transport of the site contamination, specifically, that no contaminant loss or transformation occurs. Thus, the data chosen to represent exposure point concentrations in the sample-by-sample risk calculations are an additional source of potential error.

The depth at which a soil sample was collected was not considered in the risk characterization, so exposure to subsurface contamination was considered to be equally likely as exposure to surface contamination. This approach would tend to overestimate the true risk.

The estimation of exposure requires many assumptions to describe potential exposure situations. There are uncertainties regarding the likelihood of exposure, frequency of contact with contaminated media, the concentration of contaminants at exposure points, and the time period of exposure. These tend to simplify and approximate actual site conditions. In general, these assumptions are intended to be conservative and yield an overestimate of the true risk or hazard.

The toxicological database is also a source of uncertainty. The EPA has outlined some of the sources of uncertainty in the database (EPA 1986a,b, 1989a). These sources include extrapolation between exposure routes, from high to low doses, and from animals to humans;

species, gender, age, and strain differences in uptake, metabolism, organ distribution, and target site susceptibility; and human population variability with respect to diet, environment, activity patterns, and cultural factors. The toxicity factors from IRIS and HEAST, which are used to estimate the toxicity of the COCs, are developed using a highly conservative methodology and probably tend to overestimate the potential hazards to humans.

Use of the provisional RfDs and SFs for DRPH, GRPH, and RRPH are an additional source of uncertainty in the toxicity assessment and risk characterization. Although the provisional RfDs represent the best available numerical estimate of toxicity, there is a significant amount of uncertainty associated with their use at the Point Barrow installation. The RfDs and SFs are based on studies in mice and rats by the inhalation route of exposure; whereas, in this risk assessment, exposure of humans by the ingestion route only is being evaluated. Furthermore, in the absence of more thorough studies to compare the toxicity of DRPH, GRPH, and RRPH to the toxicity of known refinery streams, it is not clear how well the provisional values represent the toxicity of diesel, gasoline, and residual oils in humans.

In the risk characterization, the assumption was made that the total risk of developing cancer from exposure to site contaminants is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancer adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach does not account for the possibility that chemicals act synergistically or antagonistically but probably results in an overestimate of the true risk.

In addition to the more general sources of uncertainty associated with risk assessment methodology, there are site-specific sources of uncertainty. Primarily, these sources are associated with the lifestyle of the native northerners, the time spent on the sites that were investigated during the RI, and specific exposure assumptions (soil ingestion rate, exposure frequency, and exposure duration).

Inhabitants of Point Barrow are not known to use the installation as an access route for recreation or subsistence hunting. No studies have been conducted to measure the time these potential receptors spend on contaminated sites at the installation. Some of the sites with levels of contamination that exceed regulatory benchmarks are not likely to be accessed by this group. Therefore, the assumptions made regarding exposure frequency probably result in an overestimate of the true noncancer hazard and cancer risk.

Similarly, no studies have been conducted to measure the soil ingestion rate of potential receptors on the contaminated sites. Soil ingestion by potential future inhabitants at Point Barrow (assuming a potential residential scenario) may be greater than the default rate of 100 mg/day for adults and 200 mg/day for children. Given the rugged, partially subsistence, lifestyle of this group, it is possible that they incidentally ingest soil at a higher rate than receptors of a similar age in the continental United States. The estimate of soil ingestion rate used in this risk assessment may over- or underestimate the true rate.

The maximum exposure duration assumed for native northerners, 55 years, is probably fairly accurate. The RME estimate for inhabitants of the continental United States is 30 years, however,

native northerners are more likely to remain in their villages for a longer period. Although, the exposure duration of 55 years is an estimate, it is not expected to significantly over- or underestimate hazard or risk.

2.6 RISK ASSESSMENT SUMMARY AND CONCLUSIONS

The human health risks associated with exposure to contaminated media (soil, sediment, or surface water) at three sites at the Point Barrow radar installation were evaluated in this risk assessment. The risk assessment was developed using a three step process:

- 1) The maximum concentrations of the chemicals detected in each medium (soil, sediment, or surface water) were compared to background concentrations, RBSLs, and ARARs. Chemicals present at concentrations that exceeded their background concentration and either an RBSL or ARAR were retained as COCs for the risk assessment.
- 2) In the risk characterization, the noncancer HQ, the excess lifetime cancer risk, or both were calculated based on the maximum concentration of each COC and the associated toxicity values developed by EPA.
- 3) The HQs for each COC at a given site were summed and the sum (called a Hazard Index) was compared to the regulatory benchmark for noncancer hazard: a hazard index of 1. Sites where the hazard index exceeded 1 were considered to warrant either remediation or further discussion. Sites where the hazard index was less than 1 are considered to warrant no further action (EPA 1991c).

The cancer risks for each carcinogenic COC at a given site were also summed and the sum (the total cancer risk) was compared to the regulatory benchmark for cancer risks: an excess lifetime cancer risk of 1×10^{-6} (one in one million). Sites where the total cancer risk exceeded 1×10^{-6} are considered to warrant further discussion. Sites where the total cancer risk was less than 1×10^{-6} are considered to warrant no further action (EPA 1991c).

Table 2-11 contains a summary of the noncancer hazard and excess lifetime cancer risk for each site and medium at the Point Barrow installation that exceeds a regulatory benchmark of 1.0 for noncancer hazard index or 1×10^{-6} for excess lifetime cancer risk.

No Further Action. The Garage (SS02) site does not warrant further investigation or discussion based on the noncancer hazard index and the excess lifetime cancer risk (Table 2-9). The hazard index was less than one for exposures to soil/sediment. The excess lifetime cancer risk was less than 1×10^{-6} for exposure of DEW Line workers to soil/sediment. The cancer risk for the native northern adult/child receptor group, however, slightly exceeds a cancer risk of 1×10^{-6} . This is discussed further below. No surface water COCs were identified for this site because no surface water bodies existed at the time of the RI.

TABLE 2-11. SUMMARY OF SITES WITH CONTAMINATION THAT EXCEEDS REGULATORY BENCHMARKS
[Noncancer Hazard Index > 1.0, Excess Lifetime Cancer Risk > 1×10^{-6}]

SITE	MEDIUM	NONCARCINOGENIC COCs ^a	NONCANCER HAZARD			CARCINOGENIC COCs ^a	EXCESS LIFETIME CANCER RISK		
			DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD		DEW LINE WORKER	NATIVE NORTHERN ADULT	NATIVE NORTHERN ADULT/CHILD
Diesel Fuel Spill (SS01)	Surface Water	GRPH	--	--	--	GRPH Benzene	6×10^{-6}	3×10^{-5}	--
Garage (SS02)	Soil or Sediment	DRPH GRPH PCBs (Aroclor 1254)	--	--	--	GRPH PCBs (Aroclor 1254)	--	--	2×10^{-5}
Air Terminal Area (SS03)	Soil or Sediment	DRPH GRPH Arsenic	--	--	--	GRPH Arsenic	--	--	3×10^{-6}
	Surface Water	GRPH	--	--	--	GRPH Benzene	9×10^{-6}	6×10^{-5}	--

^a All COCs are listed regardless of whether they contribute to the hazard index or cancer risk.
 Noncancer Hazard Index < 1.0, Excess Lifetime Cancer Risk < 1×10^{-6} .

Sites That Warrant Further Discussion. The presence of GRPH in the surface water at the Diesel Fuel Spill (SS01) site yields an excess lifetime cancer risk of 3×10^{-5} for the native northern adult and 6×10^{-6} for the DEW Line worker. These cancer risks slightly exceed the regulatory benchmark of 1×10^{-6} or a one in one million cancer risk. At the Air Terminal Area (SS03) site, the presence of GRPH and benzene in the surface water also yields excess lifetime cancer risks that fall in the range of 1×10^{-6} to 1×10^{-4} . Excess lifetime cancer risks that fall in this range are generally considered not to warrant further investigation or remediation (EPA 1991c). As noted in the exposure assessment section, surface water ingestion is not a complete pathway under current conditions and is only potentially complete under a future use scenario. The future use scenario would require decommissioning of the Point Barrow installation, release of the installation for civilian use, and redevelopment as a residential area in which the surface water was used as the sole source of water for domestic purposes. Given the low probability that surface water bodies at the installation would be developed for domestic or industrial use, the surface water at these sites does not warrant further investigation or remediation.

The presence of Aroclor 1254 in the soil at the Garage (SS02) site yields an excess lifetime cancer risk of 2×10^{-5} ; the presence of arsenic in the soil at the Air Terminal Area (SS03) yields an excess lifetime cancer risk of 3×10^{-6} . Both were calculated using the native northern adult/child scenario.

These risks slightly exceed the regulatory benchmark of 1×10^{-6} or a one in one million cancer risk. EPA generally considers excess lifetime cancer risks that fall in the range of 1×10^{-6} to 1×10^{-4} not to warrant further investigation or remediation (EPA 1991c). The northern adult/child scenario is based on residential exposure assumptions, which, to actually occur, would require that the installation be decommissioned, released for civilian use, and redeveloped as a residential area. The likelihood of this scenario is low given that the Air Force intends to continue operation of the Point Barrow installation.

In conclusion, based on the human health risk assessment remediation of the three sites evaluated at Point Barrow does not appear to be warranted. The estimates of noncancer hazard for each pathway/receptor combination were all below one, and the estimates of cancer risk for each pathway/receptor combination were all within or below the range of cancer risk that EPA considers acceptable.

3.0 ECOLOGICAL RISK ASSESSMENT

The objective of this ERA is to estimate potential impacts to aquatic and terrestrial plants and animals at the Point Barrow DEW Line installation based on sampling and analyses conducted during the RI of the three sites located at the installation. The RI was completed during the summer of 1993 in conjunction with RIs at seven other radar installations.

Guidance documents used during preparation of this assessment include:

- Handbook to Support the Installation Restoration Program Statements of Work (U.S. Air Force 1991);
- Framework for Ecological Risk Assessment (EPA 1992a); and
- Ecological Risk Assessment Guidance for Superfund (EPA 1994b).

The approach used to assess potential ecological impacts is conceptually similar to that for human health risks; potentially exposed populations (receptors) are identified, and then information on exposure and toxicity are combined to derive estimates of risk. The ERA focuses, however, on potential impacts to a population of organisms rather than individual organisms (except in the case of endangered species where individuals are considered). Because ecosystems are composed of a variety of species, ERAs evaluate potential impacts to numerous species.

Ideally, ERAs should evaluate potential risks to communities and ecosystems, as well as to individual populations. Because of the large number of species and communities present in natural systems such ecosystem-wide assessments are very complex and appropriate assessment methodologies have not yet been developed. In addition, dose-response data on community or ecosystem responses generally are lacking. Therefore, evaluations of potential impacts to communities or ecosystems are qualitative.

The degree to which potential ecological impacts can be characterized is highly dependent upon the data available to support such estimates. Such data include: information regarding contaminant release, transport and fate of COCs; characteristics of potential receptor population; and adequate supporting toxicity data for the chemicals evaluated.

This ERA is intended to be at a screening level, rather than a full scale investigation of the state of the ecosystem. No site-specific studies of the biota were undertaken. It is based on media sampling (i.e., surface water and soil/sediment samples) and is divided into six sections:

- Section 3.1 - Selection of Site Contaminants;
- Section 3.2 - Exposure Assessment;
- Section 3.3 - Ecological Toxicity Assessment;
- Section 3.4 - Risk Characterization for Ecological Receptors;

Section 3.5 - Ecological Risk Assessment Uncertainty Analysis; and
Section 3.6 - Summary of Ecological Risk.

3.1 SELECTION OF SITE CONTAMINANTS

A stressor in the environment is a chemical, physical, or biological action that can cause a negative impact on an ecosystem (EPA 1992a). Only chemical stressors, identified as chemicals of concern (COCs), are evaluated as part of this ERA. A review of the site data indicates that the chemical stressors are primarily petroleum products, solvents, and metals.

COCs are selected based on comparisons of the maximum detected concentrations to background concentrations and action levels [Federal Ambient Water Quality Criteria (AWQC) for surface water; ADEC Water Quality Standards (18 AAC 70.020[b]) January 1995; Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota (Suter and Mabrey 1994); ADEC determination of cleanup levels for petroleum contaminated soils; EPA sediment quality criteria (as estimated by Hull and Suter 1994); and NOAA Sediment Effects Range (Low) (NOAA 1991)]. If no action levels were available, the maximum detected concentration of the chemical was compared to a toxicity value derived from acute or chronic exposure tests available in the literature. If the maximum concentration was above this level, the compound was considered a COC. Chemicals present onsite at concentrations in excess of background concentrations and action levels were evaluated for frequency of detection in onsite media. If a chemical was detected at a frequency of less than five percent, it was not considered representative of actual site conditions, and was eliminated from evaluation in the risk assessment. Further, an attempt was made to eliminate elements that were within the range of natural background levels. To that end, if the average concentration (exposure concentration) of a chemical was below the maximum background concentration (i.e., if the average falls within the range of background), and if the maximum detected concentration was less than twice the maximum background concentration (which is meant to approximate the 95 percent UCL of background concentrations), the chemical was not considered a COC. Note that this criterion is used to account for outliers (i.e., hotspots) that are not representative of the distribution and concentration of chemicals to which ecological receptors may be exposed. Tables 3-1 and 3-2 present the data used in the screening process for surface water and soil/sediment. Only chemicals that were detected in at least one environmental sample are presented in these summary tables.

In summary, the decisions for selecting COCs were made using the following logic:

STEP ONE: Is the chemical detected above the maximum detected background concentration?

No:	Not considered a COC.
Yes:	Continue to step two.

TABLE 3-1. SUMMARY OF CHEMICALS OF CONCERN: SURFACE WATER

CHEMICALS OF CONCERN: POINT BARROW INSTALLATION SURFACE WATER						
CHEMICAL	RANGE OF DETECTED CONCENTRATIONS (µg/L)	BACKGROUND (µg/L) Organics = Pt. Barrow Inorganics = seven arctic DEW Line installations	ACTION LEVEL (µg/L)	FREQUENCY OF DETECTION	AVERAGE CONCENTRATION FOR COC (µg/L)	SELECTED AS COC
ORGANICS						
GRPH	136 - 1,590	<50	---	4/13	260	YES
Benzene	2 - 83	<1	5,300 ^a	3/13	7.6	NO
Toluene	2 - 74	<1	17,500 ^a	2/3	34	NO
Ethylbenzene	4.8 - 42	<1	32,000 ^a	2/3	6.1	NO
Xylenes (total)	6.5 - 380	<2	62,308 ^b	3/3	120	NO
sec-Butylbenzene	1.5	<1	---	1/3	0.80	NO
1,2-Dichloroethane	1 - 1.1	<1	20,000 ^c	2/3	0.90	NO
Isopropylbenzene	4.8	<1	---	1/3	1.9	NO
p-Isopropyltoluene	4	<1	---	1/3	1.7	NO
Naphthalene	0.8 - 58	<1 - <25	620 ^b	3/3	21	NO
n-Propylbenzene	4.1	<1	---	1/3	1.7	NO
1,2,4-Trimethylbenzene	2.6 - 92	<1	---	3/3	35	NO
1,3,5-Trimethylbenzene	3.2 - 52	<1	---	3/3	20	NO
INORGANICS - based on total metals						
Barium	120	<50 - 93	5,800 ^b	1/2	73	NO
Calcium	36,500 - 41,000	4,500 - 88,000	116,000 ^b	2/2	39,000	NO

^a EPA Ambient Water Quality Criteria (AWQC): Value presented is the Lowest Observed Effect Level (LOEL).

^b Based on the Lowest Chronic Value for All Organisms presented in Suter and Mabrey (1994).

^c EPA Ambient Water Quality Criteria. Fresh water chronic criteria.

^d See text, Section 3.1.1.1, for discussion of derivation of action level.

TABLE 3-1. SUMMARY OF CHEMICALS OF CONCERN: SURFACE WATER (CONTINUED)

CHEMICALS OF CONCERN: POINT BARROW INSTALLATION SURFACE WATER						
CHEMICAL	RANGE OF DETECTED CONCENTRATIONS (µg/L)	BACKGROUND (µg/L) Organics = Pt. Barrow Inorganics = seven arctic DEW Line installations	ACTION LEVEL (µg/L)	FREQUENCY OF DETECTION	AVERAGE CONCENTRATION FOR COC (µg/L)	SELECTED AS COC
Iron	2,800 - 6,000	180 - 2,800	1,000 ^c	2/2	4,400	YES
Magnesium	35,000 - 42,000	2,900 - 53,000	82,000 ^b	2/2	39,000	NO
Manganese	150-160	<50 - 510	1,100 ^b	2/2	160	NO
Potassium	7,300 - 7,950	<5,000	53,000 ^b	2/2	7,600	NO
Sodium	130,000 (2)	8,400 - 410,000	680,000 ^b	2/2	130,000	NO

^a EPA Ambient Water Quality Criteria (AWQC): Value presented is the Lowest Observed Effect Level (LOEL).

^b Based on the Lowest Chronic Value for All Organisms presented in Suter and Mabrey (1994).

^c EPA Ambient Water Quality Criteria, Fresh water chronic criteria.

^d See text, Section 3.1.1.1, for discussion of derivation of action level.

TABLE 3-2. SUMMARY OF CHEMICALS OF CONCERN: SOILS AND SEDIMENTS

CHEMICALS OF CONCERN: POINT BARROW INSTALLATION SEDIMENT AND SOIL						
CHEMICAL	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	BACKGROUND RANGE (mg/kg)	ACTION LEVEL (mg/kg)	FREQUENCY OF DETECTION	AVERAGE CONCENTRATION FOR COC (mg/kg)	SELECTED AS COC
ORGANICS						
DRPH	7.2 - 11,000	<65 - <180	500 ^b	21/33	730	YES
GRPH	0.8 - 1,200	<3 - <7	100 ^b	12/26	95	YES
RRPH	90 - 700	<130 - <360	2,000 ^b	4/21	120	NO
Benzene	0.17	<0.03 - <0.07	0.052 ^c	1/26	NC	NO
Toluene	0.04 - 1.3	<0.03 - <0.07	0.786 ^c	8/26	0.11	YES
Ethylbenzene	0.04 - 1.4	<0.03 - <0.07	4.36 ^c	11/26	0.30	NO
Xylenes (total)	0.38 - 6.9	<0.05 - <0.1	1.21 ^c	11/26	1.2	YES
Naphthalene	1.51	<3.8 - <40	0.407 ^c	1/2	1.3	NO
Styrene	0.19	<0.05	--	1/1	0.19	NO
Tetrachloroethene	0.3	<0.03 - <0.07	2.73 ^c	1/5	0.07	NO
Trichloroethene	0.6	<0.03 - <0.07	1.07 ^c	1/5	0.13	NO
1,2,4-Trimethylbenzene	0.32	<0.05	--	1/1	0.32	NO
1,3,5-Trimethylbenzene	0.50	<0.05	--	1/1	0.50	NO
2-Methylnaphthalene	1.87	<3.8 - <40	--	1/2	1.5	NO
Aroclor 1254	3.7 - 14	<0.1 - <0.4	0.17 ^c	3/6	4.8	YES
INORGANICS						
Aluminum	1,000 - 1,350	1,500 - 25,000	--	2/2	1,100	NO

NC Not calculated.

- a Not available.

b NOAA 1991, sediment ER-L (Effects Range - low).

c ADEC, Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, 17 July 1991.

d EPA Sediment Quality Criteria (estimated using equilibrium partitioning approach in Hull and Suter 1994).

NOAA 1991, Overall apparent effects threshold.

TABLE 3-2. SUMMARY OF CHEMICALS OF CONCERN: SOILS AND SEDIMENTS (CONTINUED)

CHEMICALS OF CONCERN: POINT BARROW INSTALLATION SEDIMENT AND SOIL						
CHEMICAL	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	BACKGROUND RANGE (mg/kg)	ACTION LEVEL (mg/kg)	FREQUENCY OF DETECTION	AVERAGE CONCENTRATION FOR COC (mg/kg)	SELECTED AS COC
Arsenic	9.7	<4.9 - 8.5	--	1/2	NC	NO
Barium	55.5 - 110	27 - 390	--	2/2	83	NO
Cadmium	3.9	<3 - <36	5 ^e	1/2	2.7	NO
Calcium	1,200 - 1,480	360 - 59,000	--	2/2	1,300	NO
Chromium	15.6 - 21	4.3 - 47	81 ^a	2/2	18	NO
Cobalt	31	<5.1 - 12	--	1/2	NC	NO
Copper	2.9 - 20	<2.7 - 45	34 ^a	2/2	11	NO
Iron	6,850 - 7,600	5,400 - 35,000	--	2/2	7,200	NO
Lead	93.5 - 150	<5.1 - 22	47 ^a	2/2	120	YES
Magnesium	650 - 935	360 - 7,400	--	2/2	790	NO
Manganese	24.5 - 45	25 - 290	--	2/2	35	NO
Nickel	3.4 - 5.2	4.2 - 46	21 ^a	2/2	4.3	NO
Potassium	350 - 470	<300 - 2,200	--	2/2	410	NO
Sodium	100 - 160	<160 - 680	--	2/2	130	NO
Vanadium	8.1 - 9.9	6.3 - 59	--	2/2	9.0	NO
Zinc	39.5 - 270	9.2 - 95	150 ^a	2/2	160	YES

NC Not calculated.

-- Not available.

^a NOAA 1991, sediment ER-L (Effects Range - low).

^b ADEC, Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, 17 July 1991.

^c EPA Sediment Quality Criteria (estimated using equilibrium partitioning approach in Hull and Suter 1994).

^d NOAA 1991, Overall apparent effects threshold.

STEP TWO: Is the chemical detected above the action level or toxicity value?

No: Not considered a COC.

Yes: Continue to step three.

STEP THREE: Is the chemical detected at a frequency greater than five percent?

No: Not considered a COC.

Yes: Continue to step four.

STEP FOUR: Is the average concentration of the chemical greater than the maximum background concentration, and is the maximum detected concentration greater than two times the maximum background concentration?

No: Not considered a COC.

Yes: Chemical is classified as a COC.

All data for COCs were averaged (arithmetic mean) according to media. In the case of non-detects, averages were calculated using one-half of the quantitation limits. Replicate samples were averaged and treated as one sample. Total metal concentrations were used in determining COCs in surface water. This is a conservative approach because dissolved metal concentrations (the more bioavailable fraction) can be significantly lower than total metal concentrations. Section 3.1.1 describes surface water COCs, and Section 3.1.2 describes soil and sediment COCs. Any exceptions to the selection methodology are discussed in these sections.

3.1.1 Surface Water

Analytical results from the Diesel Fuel Spill (SS01) and Air Terminal Area (SS03) were compiled and evaluated to identify the surface water COCs. Surface water samples were collected and analyzed for contaminants likely to be present at the specific sites. No surface water bodies were identified at the Garage; therefore, no surface water COCs were identified. Not all samples were analyzed for a "full suite" of parameters, but instead were analyzed for some combination of the following: diesel range petroleum hydrocarbons (DRPH), gasoline range petroleum hydrocarbons (GRPH), RRPH, benzene, toluene, ethylbenzene, and xylene (BTEX), halogenated volatile organic compounds (HVOCs), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), PCBs, pesticides, and metals. A summary of analytical results for all sampling conducted at the installation is presented in Appendix G. The following sections present the evaluation of the surface water data. Table 3-1 summarizes the evaluation and selection of COCs in surface water.

3.1.1.1 Organic Compounds. Thirteen organic compounds were detected in surface water samples collected from the Point Barrow installation: GRPH, benzene, toluene, ethylbenzene, xylenes (total), sec-butylbenzene, 1,2-dichloroethane, isopropylbenzene, p-isopropyltoluene, naphthalene, n-propylbenzene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene. This section presents the evaluation of these compounds as COCs in surface water for the ERA.

GRPH were detected in four of 13 surface water samples. The range of detected concentrations was 136 to 1,590 µg/L. GRPH were not detected in background samples at a detection limit of 50 µg/L. The average concentration of GRPH was 260 µg/L. There is no established action level for GRPH, but because these concentrations exceed the background levels, GRPH were selected as a COC.

Benzene was detected in 4 of 14 surface water samples at concentrations ranging from 2 to 83 µg/L. Benzene was not detected in background samples at a detection limit of 1 µg/L. Although the concentrations exceeded background levels, the detected concentration was well below the action level of 5,300 µg/L. As a result, benzene was not selected as a COC.

Toluene was detected in 4 of 14 surface water samples at concentrations ranging from 2 to 74 µg/L. Toluene was not detected in background samples at a detection limit of 1 µg/L. Although the concentrations exceeded background levels, they were well below the action level of 17,500 µg/L. As a result, toluene was not selected as a COC.

Ethylbenzene was detected in 5 of 14 surface water samples at concentrations ranging from 4.8 to 42 µg/L. Ethylbenzene was not detected in background samples at a detection limit of 1 µg/L. Although the concentrations exceeded background levels, they were well below the action level of 32,000 µg/L. As a result, ethylbenzene was not selected as a COC.

Xylenes (total) were detected in 6 of 14 surface water samples at concentrations ranging from 6.5 to 380 µg/L. Xylenes were not detected in background samples at a detection limit of 2 µg/L. Although the concentrations exceeded background levels, they were well below the action level of 62,308 µg/L. As a result, xylenes were not selected as a COC.

sec-Butylbenzene was detected in one of three surface water samples at a concentration of 1.5 µg/L. sec-Butylbenzene was not detected in background samples at a detection limit of 1 µg/L. sec-Butylbenzene is an alkylbenzene, a class of chemicals typically found in petroleum products (i.e., DRPH and GRPH) (ATSDR 1993a). Because there are no action levels for sec-butylbenzene and toxicity information is very limited, this chemical will be evaluated as one of the constituents of GRPH. Because GRPH are detected at higher concentrations, the evaluation of the toxicity of GRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

1,2-Dichloroethane was detected in two of three surface water samples at concentrations of 1 and 1.1 µg/L. 1,2-Dichloroethane was not detected in background samples at a detection limit of 1 µg/L. Although the concentrations exceeded background levels, they were well below the action level of 20,000 µg/L. As a result, 1,2-dichloroethane was not selected as a COC.

Isopropylbenzene was detected in one of three surface water samples at a concentration of 4.8 µg/L. Isopropylbenzene was not detected in background samples at a detection limit of 1 µg/L. Isopropylbenzene is an alkylbenzene, a class of chemicals typically found in petroleum products (i.e., DRPH and GRPH) (ATSDR 1993a). Because there are no action levels for isopropylbenzene and toxicity information is very limited, this chemical will be evaluated as one of the constituents of GRPH. Because GRPH are detected at higher concentrations, the

evaluation of the toxicity of GRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

p-Isopropyltoluene was detected in one of three surface water samples at a concentration of 4 µg/L. p-Isopropyltoluene was not detected in background samples at a detection limit of 1 µg/L. p-Isopropyltoluene is an alkylbenzene, a class of chemicals typically found in petroleum products (i.e., DRPH and GRPH) (ATSDR 1993a). Because there are no action levels for p-isopropyltoluene and toxicity information is very limited, this chemical will be evaluated as one of the constituents of GRPH. Because GRPH are detected at higher concentrations, the evaluation of the toxicity of GRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

Naphthalene was detected in all three surface water samples at concentrations ranging from 0.8 to 58 µg/L. Naphthalene was not detected in background samples at a detection limits of 1 to 25 µg/L. Although the concentrations exceeded background levels, they were below the action level of 620 µg/L. As a result, naphthalene was not selected as a COC.

n-Propylbenzene was detected in one of three surface water samples at a concentration of 4.1 µg/L. n-Propylbenzene was not detected in background samples at a detection limit of 1 µg/L. n-Propylbenzene is an alkylbenzene, a class of chemicals typically found in petroleum products (i.e., DRPH and GRPH) (ATSDR 1993a). Because there are no action levels for n-propylbenzene and toxicity information is very limited, this chemical will be evaluated as one of the constituents of GRPH. Because GRPH are detected at higher concentrations, the evaluation of the toxicity of GRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

1,2,4-Trimethylbenzene was detected in all three surface water samples at concentrations ranging from 2.6 to 92 µg/L. 1,2,4-Trimethylbenzene was not detected in background samples at a detection limit of 1 µg/L. 1,2,4-Trimethylbenzene is an alkylbenzene, a class of chemicals typically found in petroleum products (i.e., DRPH and GRPH) (ATSDR 1993a). Because there are no action levels for 1,2,4-trimethylbenzene and toxicity information is very limited, this chemical will be evaluated as one of the constituents of GRPH. Because GRPH are detected at higher concentrations, the evaluation of the toxicity of GRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

1,3,5-Trimethylbenzene was detected in all three surface water samples at concentrations ranging from 3.2 to 52 µg/L. 1,3,5-Trimethylbenzene was not detected in background samples at a detection limit of 1 µg/L. 1,3,5-Trimethylbenzene is an alkylbenzene, a class of chemicals typically found in petroleum products (i.e., DRPH and GRPH) (ATSDR 1993a). Because there are no action levels for 1,3,5-trimethylbenzene and toxicity information is very limited, this chemical will be evaluated as one of the constituents of GRPH. Because GRPH are detected at higher concentrations, the evaluation of the toxicity of GRPH will conservatively account for the incremental risk associated with low levels of alkylbenzenes.

3.1.1.2 Metals. Two surface water samples (including one set of replicate samples at the Air Terminal Area [SS03]) collected at the Point Barrow installation were analyzed for metals.

Seven inorganic analytes were detected: barium, calcium, iron, magnesium, manganese, potassium, and sodium. This section presents the evaluation of these metals as COCs for the ERA. Analytes not detected in surface water samples were aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. The background ranges presented are representative of seven arctic coast DEW Line installations. It is important to note that, in some cases, sample quantitation limits for certain metals were somewhat higher than ecologically relevant action levels. For example, in the case of copper, the sample quantitation limit was 50 µg/L. However, the current AWQC (based on a hardness value of 100 mg/L CaCO₃) for copper is 12 µg/L. As a result, an ecological risk may exist for aquatic organisms from exposure to certain metals at their sample quantitation limits. These metals include: aluminum, cadmium, chromium, copper, lead, and selenium. These issues will be addressed further in Section 3.5, Uncertainty Analysis. All concentrations of metals discussed below are results from total metal analysis.

Barium was detected in one of two surface water samples at a concentration of 120 µg/L. Background concentrations of barium ranged from <50 to 93 µg/L. The action level for barium is 5,800 µg/L, the Lowest Chronic Values for All Organisms, based on data presented in Suter and Mabrey (1994). Barium was not selected as a COC because it did not exceed the action level.

Calcium was detected in both surface water samples at concentrations of 36,500 and 41,000 µg/L. Background concentrations ranged from 4,500 to 88,000 µg/L. The action level is 116,000 µg/L based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994). Because calcium did not exceed background level, it was not selected as a COC.

Iron was detected in both surface water samples at concentrations of 2,800 and 6,000 µg/L. Background concentrations ranged from 180 to 2,800 µg/L. Iron concentrations exceed the background concentration in surface water and the 1,000 µg/L action level, so it was selected as a COC. The exposure concentration evaluated in this ERA is the average concentration of 4,400 µg/L.

Magnesium was detected in both surface water samples at concentrations of 35,000 and 42,000 µg/L. Background concentrations ranged from 2,900 to 53,000 µg/L. There is no AWQC for magnesium. An action level of 82,000 µg/L was based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994). Magnesium was not selected as a COC because it was below the maximum background concentration.

Manganese was detected in both surface water samples at concentrations of 150 and 160 µg/L. Background concentrations ranged from <50 to 510 µg/L. The action level for manganese is 1,100 µg/L based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994). Because manganese was not detected at concentrations exceeding the maximum background level, it was not selected as a COC.

Potassium was detected in both surface water samples at concentrations of 7,300 and 7,950 µg/L. It was not detected in background samples at a detection limit of 5,000 µg/L. Based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994), 53,000 µg/L was used

as the action level. Potassium was not selected as a COC because it did not exceed the action level.

Sodium was detected in both surface water samples at a concentration of 130,000 µg/L for both samples, which is within the background range of 8,400 to 410,000 µg/L. The action level for sodium of 680,000 µg/L was based on the Lowest Chronic Value for All Organisms (Suter and Mabrey 1994). Because onsite concentrations did not exceed the background level, sodium was not selected as a COC.

3.1.2 Soils and Sediments

Soil/sediment sample analytical results from the three sites were compiled and evaluated to determine the COCs. Because most ecological receptors are principally exposed to surficial soils/sediments, only samples collected from 0 to 1.5 feet were considered in this ERA. Thirty-three of the 40 soil/sediment samples collected from the sites are within this category. Of these, samples were collected and analyzed for contaminants likely to be present at the specific sites. Not all samples were analyzed for a "full suite" of parameters, but instead were analyzed for some combination of the following: DRPH, GRPH, RRPH, BTEX, HVOCs, VOCs, SVOCs, PCBs, pesticides, and metals. A summary of analytical results for all sampling conducted at the installation is presented in Appendix G. The following sections present the evaluation of the soil/sediment data for the three sites. Only compounds that were detected at the sites are discussed. Table 3-2 summarizes the evaluation and selection of COCs in soil/sediment.

3.1.2.1 Petroleum Hydrocarbons. Thirty-three soil/sediment samples were collected from the sites and analyzed for petroleum hydrocarbons. Thirty-three were analyzed for DRPH, 26 for GRPH, and 21 for RRPH. A discussion of these petroleum hydrocarbon mixtures and their toxicity is presented in Section 3.3.1.

DRPH were detected in 21 of 33 soil/sediment samples at concentrations ranging from 7.2 to 11,000 mg/kg. DRPH were not detected in background samples at detection limits of 65 to 180 mg/kg. The action level for DRPH in soils/sediments is 500 mg/kg. Because DRPH were detected at concentrations above the action level, they were selected as a COC. The exposure concentration used in the risk assessment was the average concentration of 730 mg/kg.

GRPH were detected in 12 of 26 soil/sediment samples at concentrations ranging from 0.8 to 1,200 mg/kg. GRPH were not detected in background samples at detection limits of 3 to 7 mg/kg. The action level for GRPH is 100 mg/kg. GRPH were detected at concentrations above the action level, so they were considered a COC. GRPH in soil/sediment were evaluated in the ERA as components of DRPH. Refer to Section 3.3.1 for a discussion of the toxicity of petroleum hydrocarbon mixtures.

RRPH were detected in four of 21 soil/sediment samples at concentrations ranging from 90 to 700 mg/kg. RRPH were not detected in background samples at detection limits of 130 to 360 mg/kg. The action level for RRPH is 2,000 mg/kg. RRPH were not detected at concentrations above the action level, so they were not selected as a COC.

3.1.2.2 Benzene, Toluene, Ethylbenzene, and Xylenes. Twenty-six soil/sediment samples were collected from the three sites at the Point Barrow installation and analyzed for BTEX using the 8020/8020 modified method. In addition, BTEX were detected using the VOC (8260) analysis. In the case of these duplicate analyses, the average concentration was calculated from the analytical method that produced the highest concentration. This is a conservative approach that is expected to be protective of ecological receptors. The following paragraphs summarize the analytical results.

Benzene was detected in one of 26 soil/sediment samples at a concentration of 0.17 mg/kg. Benzene was not detected in background samples at detection limits of 0.03 to 0.07 mg/kg. The action level for benzene is 0.052 mg/kg, based on the equilibrium partitioning approach presented in Hull and Suter (1994). Because benzene was detected only once in 26 samples (3.8 percent frequency), it was not selected as a COC.

Toluene was detected in eight of 26 soil/sediment samples at concentrations ranging from 0.04 to 1.3 mg/kg. Toluene was not detected in background samples at detection limits of 0.03 to 0.07 mg/kg. The action level for toluene is 0.786 mg/kg, based on the equilibrium partitioning approach presented in Hull and Suter (1994). Because toluene concentrations exceeded the action level, toluene was selected as a COC. The average concentration used in the ERA is 0.11 mg/kg.

Ethylbenzene was detected in 11 of 26 soil/sediment samples at concentrations ranging from 0.04 to 1.4 mg/kg. Ethylbenzene was not detected in background samples at detection limits of 0.03 to 0.07 mg/kg. The action level is 4.36 mg/kg, based on the equilibrium partitioning approach presented in Hull and Suter (1994). Because concentrations did not exceed action levels, ethylbenzene was not selected as a COC.

Xylenes (total) were detected in 11 of 26 samples. Xylene concentrations ranged from 0.38 to 6.9 mg/kg. Xylenes were not detected in background samples at detection limits of 0.05 to 0.1 mg/kg. The action level is 1.21 mg/kg. Xylenes were selected as a COC because concentrations were above action levels. The average concentration used in the ERA is 1.2 mg/kg.

3.1.2.3 Halogenated Volatile Organic and Volatile Organic Compounds. Five HVOCs/VOCs were detected in soil/sediment samples using the 8010 and 8260 methods for HVOCs and VOCs, respectively. The compounds detected were: tetrachloroethene, trichloroethene, styrene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene. HVOCs were not detected in background samples at detection limits of 0.03 to 0.07 mg/kg and VOCs were not detected in background samples at detection limits of 0.05 mg/kg. This section presents the evaluation of these compounds as COCs.

Tetrachloroethene was detected in one of five soil/sediment samples at a concentration of 0.3 mg/kg. The action level is 2.73 mg/kg, based on the equilibrium partitioning approach presented in Hull and Suter (1994). Because the concentration did not exceed the action level, tetrachloroethene was not selected as a COC.

Trichloroethene was detected in one of five soil/sediment samples at a concentration of 0.6 mg/kg. The action level is 1.07 mg/kg, based on the equilibrium partitioning approach presented in Hull and Suter (1994). Because the concentration did not exceed the action level, trichloroethene was not selected as a COC.

Styrene was detected in one soil/sediment sample at a concentration of 0.19 mg/kg. There is no established action level for styrene. A review of toxicity data shows NOAELs for rats orally exposed to styrene ranging from 17.5 to 200 mg/kg/day in studies 90 days or longer (ATSDR 1990a). A chronic (561 days) NOAEL for dogs exposed to styrene was reported between 200 and 400 mg/kg/day (ATSDR 1990a). Based on these reported toxicity levels, the detected concentration of 0.19 mg/kg is about two orders of magnitude below the lowest NOAEL and does not appear to pose a hazard, so styrene was not selected as a COC.

1,2,4-Trimethylbenzene was detected in one soil/sediment sample at a concentration of 0.32 mg/kg. 1,2,4-Trimethylbenzene is an alkylbenzene, a typical constituent of fuel oil (i.e., DRPH) (ATSDR 1993a). 1,2,4-Trimethylbenzene was not selected as a COC because the evaluation of the toxicity of DRPH (evaluated at a concentration of 730 mg/kg) will conservatively account for the incremental risk associated with 1,2,4-trimethylbenzene.

1,3,5-Trimethylbenzene was detected in one soil/sediment sample at a concentration of 0.50 mg/kg. 1,3,5-Trimethylbenzene is an alkylbenzene, a typical constituent of fuel oil (i.e., DRPH) (ATSDR 1993a). 1,3,5-Trimethylbenzene was not selected as a COC because the evaluation of the toxicity of DRPH (evaluated at a concentration of 730 mg/kg) will conservatively account for the incremental risk associated with 1,3,5-trimethylbenzene.

3.1.2.4 Semivolatile Organic Compounds. Two SVOCs were detected at the Point Barrow sites: naphthalene and 2-methylnaphthalene. These chemicals were not detected in background samples at detection limits ranging from 3.8 to 40 mg/kg. This section presents the evaluation of these compounds as COCs.

Naphthalene was detected in one of two soil/sediment samples at a concentration of 1.51 mg/kg. Naphthalenes are constituents of fuel oils (ATSDR 1993a). Naphthalene was not selected as a COC because the evaluation of the toxicity of DRPH (evaluated at a concentration of 730 mg/kg) will conservatively account for the incremental risk associated with naphthalene.

2-Methylnaphthalene was detected in one of two soil/sediment samples at a concentration of 1.87 mg/kg. There are no action levels available for this compound. Naphthalenes are constituents of fuel oils (ATSDR 1993a). 2-Methylnaphthalene was not selected as a COC because the evaluation of the toxicity of DRPH and GRPH (evaluated at a concentration of 730 mg/kg) will conservatively account for the incremental risk associated with 2-methylnaphthalene.

3.1.2.5 Polychlorinated Biphenyls. Aroclor 1254 was detected in three of six soil/sediment samples at concentrations ranging from 3.7 to 14 mg/kg. Aroclor 1254 was not detected in background samples at detection limits of 0.1 to 0.4 mg/kg. The action level for Aroclor 1254 is 0.17 mg/kg. Because the detected concentrations exceeded the action level,

Aroclor 1254 was selected as a COC. The average concentration used in the ERA was 4.8 mg/kg.

3.1.2.6 Metals. Sixteen inorganic analytes were detected in two soil/sediment samples collected and analyzed for metals from the Point Barrow installation. The metals detected were: aluminum, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. This section presents the evaluation of these metals as COCs in the ERA.

Aluminum was detected in both soil/sediment samples. Concentrations were 1,000 and 1,350 mg/kg. Background concentrations ranged from 1,500 to 25,000 mg/kg. Aluminum concentrations did not exceed background concentrations, so aluminum was not selected as a COC.

Arsenic was detected in one of two soil/sediment samples at a concentration of 9.7 mg/kg. Background concentrations at seven DEW Line installations ranged from non-detect, at a detection limit of 4.9 mg/kg, to a level of 7.0 mg/kg. A review of the arsenic content in soils throughout North America shows a range of 1 to 50 mg/kg (Lindsay 1979). Shacklette and Boerngen (1984) report that arsenic concentrations are greater than 10 mg/kg in 28 percent of 1,257 soil samples across the conterminous United States. Based on a comparison of the one detection to known background arsenic concentrations, arsenic was not selected as a COC.

Barium was detected in both soil/sediment samples at concentrations of 55.5 and 110 mg/kg. The background concentrations of barium ranged from 27 to 390 mg/kg. There is no action level for barium. Barium concentrations did not exceed background concentrations, so barium was not selected as a COC.

Cadmium was detected in one of two soil/sediment samples at a concentration of 3.9 mg/kg. Cadmium was not detected in background samples at detection limits of 3 to 36 mg/kg. An overall apparent effects threshold of 5 mg/kg (NOAA 1991) was used as the action level. Because the detected concentration did not exceed the action level, cadmium was not selected as a COC.

Calcium was detected in both soil/sediment samples. Concentrations were 1,200 and 1,480 mg/kg. Background concentrations ranged from 360 to 59,000 mg/kg. There is no action level for calcium. Calcium concentrations did not exceed the maximum background concentration, so this chemical was not selected as a COC.

Chromium was detected in both soil/sediment samples analyzed for metals at concentrations of 15.6 and 21 mg/kg. The maximum background concentration is 47 mg/kg. The action level for chromium is 81 mg/kg. The detected concentrations did not exceed the maximum background level, so chromium was not selected as a COC.

Cobalt was detected in one of two soil/sediment samples at a concentration of 31 mg/kg. Background concentrations at seven arctic coast DEW Line installations ranged from non-detect at 5.1 mg/kg to a level of 12 mg/kg. No action level is available for cobalt. The common range

for cobalt concentrations in U.S. soils is 1 to 40 mg/kg (Lindsay 1979; ATSDR 1990b). Because the detected cobalt concentration of 31 mg/kg falls within the bounds of the concentrations commonly found in U.S. soils, it was not selected as a COC.

Copper was detected in both soil/sediment samples. Detected concentrations were 2.9 and 20 mg/kg. Background concentrations ranged from <2.7 to 45 mg/kg. The action level for copper is 34 mg/kg. The detected concentrations did not exceed the maximum background concentration, so copper was not selected as a COC.

Iron was detected in both soil/sediment samples. Concentrations were 6,850 and 7,600 mg/kg. The background concentrations ranged from 5,400 to 35,000 mg/kg. The detected concentrations did not exceed the maximum background concentration, so iron was not selected as a COC.

Lead was detected in both soil/sediment samples at concentrations of 93.5 and 150 mg/kg. The maximum background concentration for lead was 22 mg/kg. The action level for lead is 47 mg/kg (Hull and Suter 1994). Because the detected concentrations of lead exceeded the background and action levels, it was selected as a COC. The average concentration used in the ERA was 120 mg/kg.

Magnesium was detected in both soil/sediment samples. Concentrations were 650 and 935 mg/kg. The background concentrations for magnesium ranged from 360 to 7,400 mg/kg. There is no action level for magnesium. Because magnesium was not detected above background concentrations, it was not selected as a COC.

Manganese was detected in both soil/sediment samples. Concentrations were 24.5 and 45 mg/kg. The background concentrations for manganese ranged from 25 to 290 mg/kg. There are no action levels for manganese. Because concentrations did not exceed background concentrations, manganese was not selected as a COC.

Nickel was detected in both soil/sediment samples at concentrations of 3.4 and 5.2 mg/kg. The background concentrations ranged from 4.2 to 46 mg/kg. The action level for nickel is 21 mg/kg. Nickel was not selected as a COC because concentrations did not exceed the maximum background level.

Potassium was detected in both soil/sediment samples at concentrations of 350 and 470 mg/kg. The background concentrations ranged from <300 to 2,200 mg/kg. There is no action level for potassium. Potassium was not selected as a COC because concentrations were below the maximum background concentration.

Sodium was detected in both soil/sediment samples. Concentrations detected were 100 and 160 mg/kg, which did not exceed the maximum background concentration of 680 mg/kg. There is no action level for sodium in soil/sediment. Because the detected concentration of sodium did not exceed the maximum background concentration, it was not selected as a COC.

Vanadium was detected in both soil/sediment samples at concentrations of 8.1 and 9.9 mg/kg. The background concentrations ranged from 6.3 to 59 mg/kg. There is no action level for vanadium. Vanadium was not selected as a COC because its concentrations were below the maximum background concentration.

Zinc was detected in both soil/sediment samples at concentrations of 39.5 and 270 mg/kg. The background concentrations for zinc ranged from 9.2 to 95 mg/kg. The action level for zinc is 150 mg/kg. Because zinc concentrations were above background and action levels, zinc was selected as a COC. The average concentration used in the ERA was 160 mg/kg.

3.2 ECOLOGICAL EXPOSURE ASSESSMENT

The vegetation of the Arctic Coastal Plain and the ecosystems it characterizes have developed primarily as a result of the low relief and harsh environment. The growing season is short, typically extending from June through mid-September. Winters are long, cold, dry, and dark. Air temperatures that average below freezing for most of the year result in a permafrost layer that begins near the surface and reaches to depths as great as 610 meters. Seasonal thawing results in an active layer between ground surface and 3.7 meters below the surface (Hart Crowser 1987).

The impervious permafrost layer prevents percolation and infiltration of water below the active layer, and the generally flat terrain provides poor drainage. As a result, the ecosystems of the Arctic Coastal Plain are often defined not only by their plant associations but also by the degree of water found in and on them. Hart Crowser (1987) describes five major ecosystems for the classification of tundra and Arctic Coastal Plain communities:

- Marine zones: these include lagoons, estuaries, barrier islands, strands, and beaches. The abundance of vegetation along the marine coastal zone is inversely related to the amount of beach scouring by waves and ice. Mainland beaches support a variety of vegetation including sedges, grasses, and forbs.
- Wet sedge meadows: an association of meadows, ponds, and lakes also known as "wet tundra". This system, with its associated wetlands, is dominant in the area extending west from the Colville River to the Chukchi Sea (including the Point Lonely, Point Barrow, Wainwright, Point Lay, and Cape Lisburne installations). Differences in vegetation within this ecosystem are related to moisture and microrelief.
- Tussock tundra: "moist tundra" consisting primarily of areas dominated by tussock-forming cottongrass. This system covers significant portions of the Arctic Coastal Plain.
- Riverine systems and floodplains: including riparian shrubland on recent and old alluvium. Being better drained than surrounding lands, the riparian environment supports a distinctive "shrub thicket" vegetation.

- Alpine tundra: including rocky upland areas of sparse mat-forming or fell-field vegetation.

The species associated with each ecosystem at the Point Barrow DEW Line installation have the potential to be exposed to COCs if exposure pathways are complete. If pathways are complete, the representative species selected are considered receptors. Figure 3-1, Section 3.2.3, presents a schematic model of the potential exposure pathways.

The Ecological Exposure Assessment segment of the risk assessment contains the following: the most common species found at the DEW Line installations in Section 3.2.1, species of the Arctic Coastal Plain; the representative species and the rationale used for their selection in Section 3.2.2; a discussion of the exposure pathways in Section 3.2.3; and a review of the habitat suitability for representative species in Section 3.2.4. Sections 3.2.5, 3.2.6, and 3.2.7 provide the methodology of the exposure assessment for representative plants, aquatic species, and birds and mammals, respectively. Life history tables, which provide species-specific information for use in the exposure assessment, are included in Section 3.2.7.

3.2.1 Species of the Arctic Coastal Plain

The representative species used in the ERA for the Point Barrow installation were selected from species characteristic of the DEW Line installations along the Arctic Coastal Plain and are detailed in Sections 3.2.2.1 through 3.2.2.5.

The Point Barrow installation is located along the northern boundary of the Arctic Coastal Plain. Hart Crowser (1987) and Woodward-Clyde (1993) have listed the species likely to occur along the coastal plain based on site-specific studies and a review of the literature. The marine zone, wet sedge meadows, tussock tundra, and riverine/riparian are the primary ecosystems found at the Point Barrow installation. Alpine tundra is minimal at the site and is not evaluated further. Site-specific surveys of the ecosystems associated with the DEW Line installations have not been conducted for this risk assessment; however, a study investigating the abundance and distribution of Steller's and spectacled eiders was used (Alaska Biological Research 1994).

3.2.1.1 Plants. Plants commonly associated with the marine zone are sedges, grasses, and forbs. *Carex subspathacea* and *C. aquatilis* are dominant plants in the coastal wetlands.

The wet sedge meadow (also known as "wet tundra") is characterized by a variety of sedges and grasses. Typical species include cottongrass, *Eriophorum* spp.; tundra grass, *Dupontia fischeri*; and mosses, *Sphagnum* spp. Marsh marigold, *Caltha palustris*; and horsetail, *Equisetum* spp. may be found in wetter areas (Hart Crowser 1987).

The tussock tundra (or moist tundra) is drier than the wet sedge meadow/wet tundra association. Tussock-forming cottongrass is the dominant plant species. Grasses, sedges, dwarf shrubs, mosses, and lichens are scattered throughout the tussock complex. These species include willows, *Salix* spp.; Labrador tea, *Ledum palustre*; blueberry and lingonberry, *Vaccinium* spp.; and lousewort, *Pedicularis* spp. (NPRA Task Force 1978; Bergman et al. 1977).

Riverine/riparian systems are composed of a diversity of habitat types and species. The dominant plants are low growing shrubs with a scattered understory of grasses and herbs. Larkspur, *Delphinium brachycentrum*; cinquefoil, *Potentilla* spp.; bearberry, *Arctostaphylos* spp.; and wormwood, *Artemisia arctica*, are common species (NPRA Task Force 1978; Bergman et al. 1977).

3.2.1.2 Aquatic Organisms. Sixty-six species of fish inhabiting marine, estuarine, and freshwater systems have been identified in the arctic region (Hart Crowser 1987). Marine species inhabiting the nearshore and offshore waters include boreal smelt, *Osmerus eperlanus*; Pacific herring, *Clupea harengus*; arctic cod, *Boreogadus saida*; and fourhorn sculpin, *Myoxocephalus quadricornis*. Anadromous species using arctic rivers for spawning include the arctic cisco, *Coregonus autumnalis*; arctic char, *Salvelinus alpinus*; and occasional pink and chum salmon, *Oncorhynchus* spp. Lack of overwintering habitat is a significant limiting condition for both anadromous and freshwater fish of the arctic region. The principal freshwater fish found in the region are grayling, *Thymallus arcticus*; lake trout, *Salvelinus namaycush*; burbot, *Lota lota*; and nine-spined stickleback, *Pungitius pungitius* (Hart Crowser 1987).

Invertebrates that may be present in the waters and wet habitats of the Arctic Coastal Plain are well represented by the crustaceans (i.e., copepods, isopods, amphipods, and decapods).

3.2.1.3 Birds. There are approximately 180 species of birds seasonally associated with the habitats of the Arctic Coastal Plain. Of these, many are shorebirds and waterfowl using migratory corridors that pass through the Point Barrow area. Bird use of the coastal plain is highly seasonal and associated with typical avian breeding and migration cycles. Shoreline habitats are used significantly in association with molting, pre-migratory staging, and post breeding movement. These habitats are considered critical by the U.S. Fish and Wildlife Service (USFWS 1982). Principal species include glaucous gull, *Larus hyperboreus*; red phalarope, *Phalaropus fulicaria*; dunlin, *Calidris alpina*; loons, *Gavia* spp.; sandpipers, *Calidris* spp.; eiders, *Somateria* spp.; and geese, *Branta* spp. and *Chen* sp. Among the migratory passerine species using the coastal habitats are the Savannah sparrow, *Passerculus sandwichensis*; common and hoary redpolls, *Carduelis* spp.; snow bunting, *Plectrophenax nivalis*; and Lapland longspur, *Calcarius lapponicus* (Woodward-Clyde 1993).

3.2.1.4 Mammals. The mammalian fauna of the Arctic Coastal Plain and adjacent waters is relatively simple compared to fauna at lower latitudes. A review of species lists indicates a total of 38 species that commonly occur in the arctic; 11 of these are marine mammals (Hart Crowser 1987). A sampling of the terrestrial mammals geographically associated with the DEW Line stations, including Point Barrow, consists of: brown lemming, *Lemmus trimucronatus*; masked shrew, *Sorex cinereus*; arctic fox, *Alopex lagopus*; red fox, *Vulpes vulpes*; weasels, *Mustela* spp.; tundra vole, *Microtus oeconomus*; caribou, *Rangifer tarandus*; and grizzly bear, *Ursus arctos* (Hart Crowser 1987; Woodward-Clyde 1993).

Marine mammals of the arctic coast include polar bear, *Ursus maritimus*; walrus, *Odobenus rosmarus*; six species of whales; and five species of seals. The most common of the whale and seal species are beluga, *Delphinapterus leucas*; bowhead whale, *Balaena mysticetus*; gray whale,

Eschrichtius robustus; ringed seal, *Phoca hispida*; and bearded seal, *Erignathus barbatus* (Hensel et al. 1984).

3.2.1.5 Threatened and Endangered Species. Species of the Arctic Coastal Plain and nearby waters that are protected by federal and state designations include bowhead whale (endangered); fin whale, *Balaenoptera physalus* (endangered); sei whale, *Balaenoptera borealis* (endangered); and humpback whale, *Megaptera novaengliae* (endangered). The gray whale was delisted by the National Marine Fisheries Service as of 16 June 1994. Avian species include the spectacled eider, *Somateria fischeri* (threatened), and Steller's eider, *Polysticta stelleri* (candidate for listing). Based on the latest federal and state lists of threatened and endangered plant species (June 1995), no plant species at the DEW line installations are currently listed.

3.2.2 Representative Species

It is impractical to evaluate all of these potential receptors individually because of the great diversity of plants and animals at a given site. Thus, for ERAs, a set of "representative species" is selected for further evaluation. The representative species are selected primarily on the species' likelihood of exposure given their preferred habitat, feeding habits, and distribution of contaminants. Potential exposure pathways are shown in Figure 3-1 and discussed in Section 3.2.3. The abundance of a species relative to the areal extent of the sites is also considered. The representative species encompass a range of ecological niches in order to achieve the best characterization of ecosystems being examined. In addition, species are selected, in part, as a result of the availability of toxicity, exposure, and life history information. Species that may be sensitive to environmental impacts, such as endangered or threatened species, are also evaluated. Any endangered or threatened species discussed in the ERA are not considered representative of the Arctic Coastal Plain or the Air Force arctic radar installations. These species are evaluated to provide information about whether they face potential risks from exposure to the COCs being evaluated in the ERA.

For the DEW Line stations, the groups of receptors evaluated include plants, aquatic invertebrates, fishes, birds, and mammals. Potential risks to representative species are estimated by evaluating sampling data for the relevant exposure media (i.e., soil, sediments, and surface water). For plants, soil/sediment COC data are used to estimate potential uptake. For aquatic species, surface water COC concentrations are used to estimate exposure, and for birds and mammals, exposures are estimated by evaluating their potential dietary intakes of COCs. No site-specific studies were conducted to determine exposure or toxicity levels at the installation.

The similarity of ecosystems at each of the installations allows the use of the same set of representative species for all installations. It may be possible that a representative species inhabits the general area of an installation, but does not occur specifically on the installation property. When and if this situation occurs, it will be noted. The receptors selected as representative species for the Point Barrow installation are listed in the paragraphs that discuss the representative groups (i.e., plants, aquatic organisms, birds, mammals, and threatened or endangered species). Table 3-3 presents the representative and sensitive species for arctic coastal DEW Line installations, including endangered and threatened species that potentially may

TABLE 3-3. REPRESENTATIVE AND SENSITIVE SPECIES AT THE ARCTIC DEW LINE INSTALLATION SITES^a

COMMON NAME	GENUS AND SPECIES
PLANTS	
Sedge	<i>Carex spp.</i>
Cottongrass	<i>Eriophorum spp.</i>
Willow	<i>Salix spp.</i>
Berries	<i>Vaccinium spp.</i>
AQUATIC ORGANISMS	
Water fleas	<i>Daphnia spp.</i>
Nine-spined stickleback	<i>Pungitius pungitius</i>
Arctic char	<i>Salvelinus alpinus</i>
BIRDS	
Lapland longspur	<i>Calcarius lapponicus</i>
Brant	<i>Branta bernicla</i>
Glaucous gull	<i>Larus hyperboreus</i>
Pectoral sandpiper	<i>Calidris melanotos</i>
MAMMALS	
Brown lemming	<i>Lemmus trimucronatus</i>
Arctic fox	<i>Alopex lagopus</i>
Barren-ground caribou	<i>Rangifer tarandus</i>
ENDANGERED AND THREATENED SPECIES[*]	
Spectacled eider ^b	<i>Somateria fischeri</i>
Steller's eider ^c	<i>Polysticta stelleri</i>

^{*} See Section 3.2.2.5 for information about endangered and threatened species.

^a These representative species were selected for seven DEW Line installations (Barter Island, Bullen Point, Oliktok Point, Point Lonely, Point Barrow, Wainwright, and Point Lay) and the Cape Lisburne radar installation.

^b Threatened status.

^c Candidate for threatened status, see text for explanation.

be exposed. The USFWS was consulted about the occurrence and selection of threatened and endangered species.

3.2.2.1 Representative Plants. Plants selected as representative species are sedges, willows, cottongrass, and various berry-bearing plants, *Vaccinium* spp. These species were selected because they are abundant on all the sites, are important links in the trophic structure of the ecosystems of the arctic, and represent a major percentage of the primary production along the coastal plain. The blueberry, huckleberry, and lingonberry, *Vaccinium* spp., are also evaluated because of their roles as forage plants and as subsistence species. All of these representative species are evaluated at the Point Barrow installation.

3.2.2.2 Representative Aquatic Invertebrates and Fish. The invertebrates selected as representative species are *Daphnia* spp. (water fleas). The nine-spined stickleback is the representative fish species. The arctic char is not evaluated at the Point Barrow installation because it is unlikely that the exposure pathways are complete. *Daphnia* spp. are abundant and represent a portion of the diet of the selected fish species (Johnson and Burns 1984; Wootton 1976), and toxicity information is readily available for them. The nine-spined stickleback is a freshwater species that also uses brackish habitats, nests in aquatic vegetation, and is prey for other fish and bird species (Wootton 1976). No marine mammals are evaluated in the Point Barrow ERA because there are no complete pathways for COCs (at concentrations that are of concern) to reach potential marine receptors.

3.2.2.3 Representative Birds. The representative avian species are Lapland longspur; brant, *Branta bernicla*; glaucous gull; and pectoral sandpiper, *Calidris melanotos*. The Lapland longspur is a passerine belonging to a terrestrial feeding guild (including sandpipers, turnstones, and phalaropes) (Custer and Pitelka 1978). The longspur's diet of insects and seeds (Custer and Pitelka 1978) makes it an important link in the arctic trophic web. The brant nests and molts among the numerous ponds in the tussock tundra and grazes on sedges and cottongrass (Palmer 1976). It is considered to be an important subsistence resource. The glaucous gull is a predatory scavenger that feeds on small mammals, young birds, carrion, and garbage; and breeds along the Arctic Coastal Plain (Farrand 1983). The pectoral sandpiper is an abundant shorebird that is primarily insectivorous and breeds on the Arctic Coastal Plain. The Lapland longspur, brant, glaucous gull, and pectoral sandpiper are in potential exposure pathways at the Point Barrow installation and are evaluated in this ERA. All the avian species in this ERA are migratory, and as such, are protected under the Migratory Bird Treaty Act of 1978. This is reflected by the use of a protected species factor of 2 in the calculation of avian toxicity reference value (TRV).

3.2.2.4 Representative Mammals. The representative species of mammals are the brown lemming, arctic fox, and barren-ground caribou. The brown lemming is the predominant small mammal at all installations. The lemming consumes more vegetation than expected for an animal its size, due to its low assimilation efficiency, the low nutrient value of winter forage, and the high metabolic demands of the arctic environment (Chappell 1980). The arctic fox is selected as a representative species because it is ubiquitous along the coastal plain, and its carnivorous diet (mostly lemmings) places it near the top of the trophic structure in the arctic. Eberhardt et al. (1982) note that in fall and winter, and to a lesser extent in summer, the arctic fox frequently

uses areas near development. This tendency may expose the fox to pathways of contamination. Additionally, the fox, a relatively common furbearer, can be an important subsistence resource. The caribou is selected as a representative species because it uses areas on, or near, a number of the radar installations during migration, calving, and post-calving. In addition, the caribou is a significant subsistence resource for local people along the Arctic Coastal Plain (USFWS 1982; Cuccarese et al. 1984; Hensel et al. 1984). The three mammal species discussed may be exposed to COCs at the Point Barrow installation and are evaluated in this ERA.

3.2.2.5 Threatened and Endangered Species. The threatened and endangered species that potentially occur at the DEW Line installations are the spectacled eider and Steller's eider. The spectacled eider is federally listed as threatened, and Steller's eider is a candidate for listing as threatened. The U.S. Fish and Wildlife Service indicated that it was likely that Steller's eider would be listed as threatened sometime in 1995 (Ambrose 1994 pers. comm.), but a federal moratorium on additions to the threatened and endangered lists is in effect. Alaska Biological Research (1994) conducted surveys searching for spectacled and Steller's eiders on and near the DEW Line installations. The surveys report that there is a moderate chance that these species may nest or rear broods in the habitats near Point Barrow. The spectacled eider will be evaluated in this ERA. Because of the ecological similarity of spectacled and Steller's eiders (i.e., relatively similar morphology, physiology, niche, and trophic status), the evaluation of the spectacled eider will serve as a surrogate risk indicator for Steller's eiders in the event that the species has a complete exposure pathway to a COC at the Point Barrow installation. The arctic peregrine falcon, *Falco peregrinus tundrius*, was delisted by the USFWS on 5 October 1994.

3.2.3 Exposure Pathways

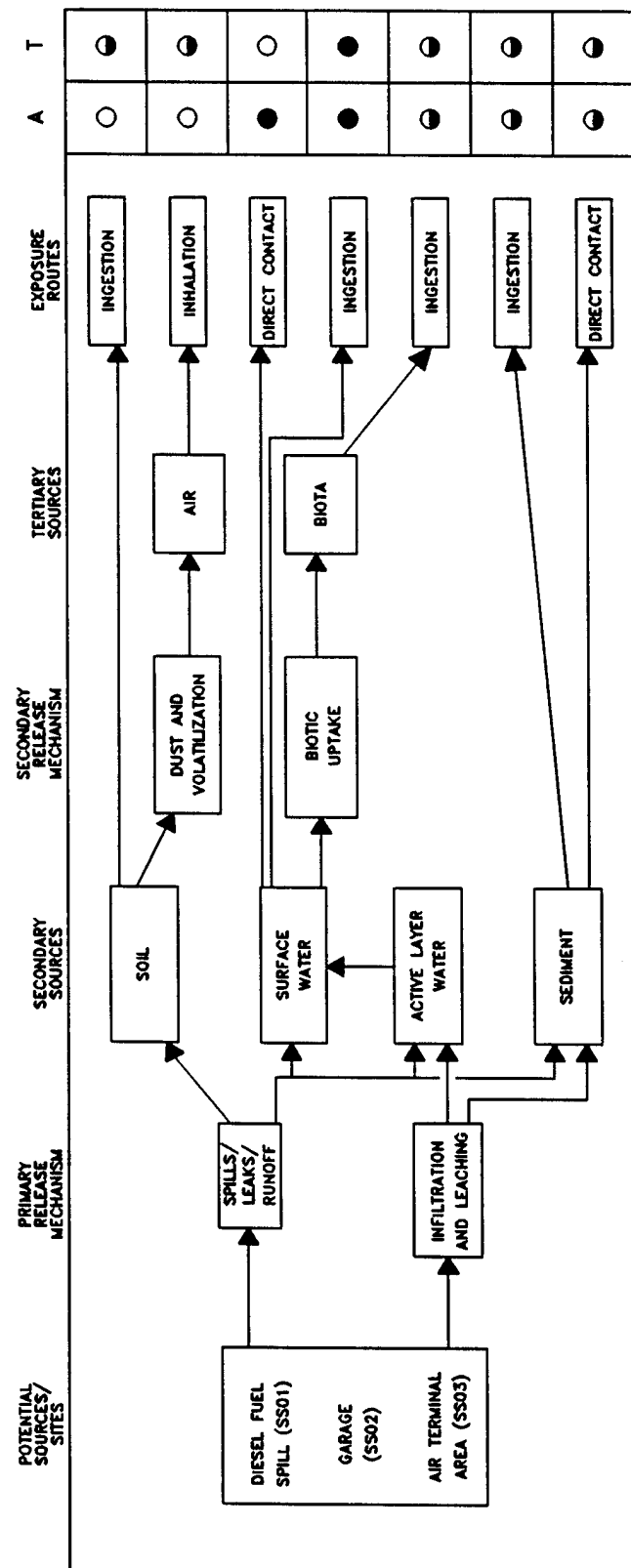
This section discusses potential exposure pathways for ecological receptors. In addition, methods used to quantify exposures to selected species of plants, aquatic organisms, birds, and mammals are presented. Quantitative estimates of exposure will be compared with TRVs derived in Section 3.3 to estimate risks in the risk characterization section (Section 3.4).

Ecological receptors can be exposed to COCs through abiotic and biotic media. Potential exposure pathways for terrestrial and aquatic organisms are summarized in Figure 3-1. The following sections describe the potential exposure routes and a determination of pathways evaluated in the risk assessment.

Potential risks to representative species of plants from exposure to COCs in soil and water will be addressed. The most significant route of exposure for plants is direct contact with soil at the site, although a qualitative evaluation of the effects of COCs in surface water is presented in Section 3.4.1.

Aquatic organisms such as fish and invertebrates are primarily exposed through direct contact with surface water. Surface water is in direct contact with dermal surfaces as well as gills and other respiratory structures. Fish and invertebrates also may be exposed to COCs through ingestion of plant and animal items in the diet, direct contact with sediments, and incidental ingestion of sediments while foraging. Direct contact with surface water is the primary exposure

DRAWING No. BRW-FLO2



**POINT BARROW
RADAR INSTALLATION**

USAF 611th CES

FIGURE NO. 3-1

**ECOLOGICAL RISK
ASSESSMENT
POTENTIAL EXPOSURE
PATHWAYS**

- A AQUATIC RECEPTORS
- T TERRESTRIAL RECEPTORS
- COMPLETE EXPOSURE PATHWAY
- ◐ POTENTIALLY COMPLETE PATHWAY
- INCOMPLETE OR INSIGNIFICANT EXPOSURE PATHWAY

THIS PAGE INTENTIONALLY LEFT BLANK

route; therefore, these secondary routes (ingestion and direct contact) will not be evaluated for aquatic organisms.

Birds and mammals may be exposed to COCs through a variety of pathways including ingestion of surface water used for drinking, ingestion of plant and animal diet items, and incidental ingestion of surface soils and sediments while foraging. Wildlife species are not expected to be exposed to COCs via inhalation because the surface soils are well vegetated and moist during the growing season and frozen and/or snow covered the remainder of the year. Therefore, the inhalation pathway is not evaluated in the ERA.

Insufficient toxicity and exposure information is available for the representative species to allow quantification of exposures from dermal contact with soil or sediments; therefore, these pathways were not quantitatively evaluated. Because soils and sediments represent potential pathways, total exposures for the representative species could be underestimated. This represents one of the uncertainties discussed in Section 3.5 of this risk assessment.

The soil and sediment samples at the Point Barrow installation were taken at depths ranging from the surface to four feet deep. Only samples at depths of 1.5 feet or less were used in the ERA because the potential exposure pathways for the representative species are likely to be incomplete at depths greater than 1.5 feet. It is unlikely that any of the representative species would be exposed to soil or sediments much below one foot, although the brown lemming is reported to burrow up to one foot deep (Nowak 1991).

3.2.4 Habitat Suitability for Representative Species

In order to assess the representative species' degree of exposure to the COCs, the habitat suitability of each of the three sites was evaluated. The habitat suitability evaluation considered the representative aquatic, avian, and mammalian species at the Point Barrow installation.

Human development and activities at the Point Barrow installation have impacted the natural habitats available to the representative species. The effects of these impacts are uncertain; in some cases the activities probably deter wildlife use of the area and in other cases they may attract wildlife (e.g., arctic fox and gulls attracted to a landfill). Although these impacts may affect how and when representative species may use the habitats at Point Barrow, the impacts are not subject to quantification, so all the sites at the Point Barrow installation are evaluated in this ERA. In some cases, the media-specific samples have been taken at locations that do not represent suitable habitat for all the representative species (e.g., under-building sample locations that are obviously not suitable for caribou, or surface water sample locations that are not suitable for fish species). This may result in an overestimate of exposure because sample data from all locations are used to calculate the average concentrations which, in turn, are used to estimate exposure for the representative species. These conditions will be noted in the risk characterization and uncertainty discussions (Sections 3.4 and 3.5, respectively).

The ERA is being conducted for the entire Point Barrow installation, but only a portion of the facility consists of potentially contaminated sites. The sites are estimated to total approximately 3.9 hectare (ha), or 9.6 acres. The areal extent of the potentially contaminated sites has been

estimated using site maps. The spatial extent of the sites is considered when estimating the onsite dietary intake (IS) in Section 3.2.7.2. In general, based on professional judgement and onsite observations but not on site-specific surveys, the installation provides habitat less suitable than nearby areas because of the numerous roads, gravel pads, and overall development.

3.2.5 Exposure Assessment for Representative Species of Plants

The harsh environment of the Arctic Coastal Plain imposes many restrictions on plant life. The presence of permafrost limits infiltration and percolation of water, so the water table is often at or near the surface. Most plant species are perennial, with much of their biomass (50 to 98 percent) underground (Raven et al. 1986). The potential pathways of contamination for plants are through the soil/sediment and surface water.

Carex spp., *Salix* spp., and *Eriophorum* spp. all store food reserves in rhizomes. Mycorrhizal fungi play an important role in the transport and delivery of nutrients to the rhizomes and the roots of these species. This underground system probably developed in response to the harsh aboveground arctic environment. Surface water contaminated with chemicals that are lighter than water (i.e., petroleum and its derivatives) does not present a greatly increased hazard to the below-ground portion of plants. This has been shown experimentally by exposing arctic coast vegetation to petroleum products (Walker et al. 1978). The experiments showed that sedges, willows, and cottongrass plants were not adversely affected by low to moderate amounts of petroleum (spill concentrations in the studies were up to 12 L/m²) in wet environments. Thus, soil/sediment will be considered the primary pathway of potential contamination for plants. The chemical concentration used in the risk characterization (Section 3.4) is the average concentration of the COC in the soil/sediment at the installation. A qualitative evaluation of the effect of potentially contaminated surface water on plants is presented in Section 3.4.1.

3.2.6 Exposure Assessment for Representative Aquatic Organisms

Organisms that dwell in an aquatic environment are exposed to chemicals contained in the water column. For this reason, the exposure assessment considers the concentrations in surface water to be the exposure concentrations to aquatic organisms. As described in Section 3.2.3, the primary exposure route for aquatic organisms is direct contact with surface water, and as a result, the aquatic representative species are not evaluated for contact with, or ingestion of, sediments. The risk assessment compares the average concentration of the COCs found in surface waters to toxicity data for the representative aquatic species to calculate the risk estimate.

3.2.7 Exposure Estimates for Representative Bird and Mammal Species

Exposure estimates for representative species of mammals and birds (expressed as a unit of chemical ingested per unit of body weight) are based on their total exposure to COCs from diet, soils, and surface water using the following equation:

$$EE = [(FI \times CF) + (WI \times CW) + (SI \times CS \times ROA)] \times UCF \times IS / BW$$

where:

EE	=	estimated exposure (mg/kg-bw/day).
FI	=	food intake rate (g/day); rates are derived in the life history tables. Diets (both vegetable and animal components) are proportioned according to the diet composition information in the life history tables and are presented below.
CF	=	chemical concentration in food (mg/kg); based on concentrations for each group of food items.
WI	=	water intake rate (L/day); rates are derived in the life history tables.
CW	=	chemical concentration in water ($\mu\text{g/L}$); see Section 3.1 for calculations of concentrations.
SI	=	soil/sediment intake rate (g/day); based on a percentage of food intake.
CS	=	chemical concentration in soil/sediment (mg/kg); see Section 3.1 for calculations of concentrations.
ROA	=	relative oral availability; default to 1.0 (lack of information). This value assumes that the bioavailability of the chemical in the test medium is the same as for the medium onsite.
UCF	=	0.001; unit conversion factor used to convert g to kg, μg to mg, and L to ml, to ensure EE is reported in mg/kg-bw/day.
IS	=	fraction of dietary intake at potentially contaminated sites (by weight).
BW	=	body weight (kg).

In the case of species that have partial herbivorous dietary intakes, the CF x FI phrase in the equation is multiplied by the proportion of vegetation in their diet (these calculations are presented in Appendix C, Bioconcentration Factor Calculation, and Appendix D, Concentration in Food Calculations). Those species and their respective proportions are: Lapland longspur, 0.25; brant, 0.90; glaucous gull, 0.10; pectoral sandpiper, 0.10; and spectacled eider, 0.25 (see the life history tables for references regarding the proportion of vegetation in the species' diets). The estimated exposure calculations for bird and mammal receptors are presented in Appendix E.

3.2.7.1 Potential Bioaccumulation of COCs in Representative Species. The potential risks from ingestion of COCs in dietary items are difficult to determine because of the complexity of the trophic web. Inputs to the exposure estimate equation include concentrations of contaminants in water and soil, ingestion rates for water, food, and soil, the relative use of the potentially contaminated sites compared to the representative species' normal range, and body weight. The food ingested, in the case of higher level consumers, may be from different levels of the trophic web. For example, a contaminant may be taken up by a plant that is consumed by a lemming, which is then eaten by an arctic fox. The amount of contaminant to which the fox is exposed is not readily quantified without supporting empirical data at each trophic level. Because data is lacking to assist in quantifying bioaccumulation, the risk assessment does not account for bioaccumulation in the animal portion of the trophic web. This uncertainty is tempered by the "hot spot" nature of the distribution of the COCs. It is possible that representative species may be exposed to these "hot spots" occasionally, but it is unlikely that their entire exposure will occur at these locations. Use of the average concentrations may

overestimate the potential exposure of representative species (this is discussed in more detail in the ERA Uncertainty Analysis, Section 3.5.1). Furthermore, the likelihood of predators repeatedly taking prey that were exposed to a COC "hot spot" is low. For example, the arctic fox ranges over such a wide area that any COCs to which the fox would be exposed via bioaccumulation would represent only a very small proportion of its overall exposure.

Further, most of the COCs in soils/sediments at the Point Barrow installation were petroleum hydrocarbons and BTEX, which are unlikely to bioaccumulate. PCBs, also a COC in soil/sediment, have a high potential for bioaccumulation. This is addressed further in Section 3.4.5, Potential Future Risks. For illustrative purposes, bioconcentration factors (BCF) calculated (Veith et al. 1979 in Spacie and Hamelink 1985) for the organic COCs are presented in Table 3-4. The exposure estimates for organic chemicals do not include potential bioaccumulation of COCs in the animal portion of the trophic web. It is unlikely that the organic chemicals will bioaccumulate (based on the concentrations reported in the soil/sediment and surface water) such that the exposure estimates would exceed, or even approach, the TRVs. Bioconcentration factor calculations are presented in Appendix C.

The inorganic COCs at Point Barrow are iron in surface water and lead and zinc in soil/sediment. The bioaccumulation of metals in the animal portion of the trophic web is not amenable to quantification without sample concentrations at each level of consumer.

The following qualitative discussions address the potential bioaccumulation of the inorganic COCs at the Point Barrow installation.

Iron. Information about the bioaccumulation of iron is not available in the literature, but it is likely that metabolic processes will prevent undue bioaccumulation because iron is an essential nutrient.

Lead. Lead tends to accumulate in bone (Talmadge and Walton 1991), so ingestion of animal tissue would not contribute greatly to increased lead concentrations. Food chain biomagnification of lead is uncommon in terrestrial communities (Eisler 1988). Kraus (1989) showed that in environments high in lead (200 to 700 mg/kg in wetland sediments), the concentration of lead in insects and the tissues of insectivorous birds was low. Thus, lead is not likely to bioaccumulate to a degree that could contribute to risk at the Point Barrow installation.

Zinc. Zinc is an essential nutrient (Eisler 1993). Animal systems are conditioned to regulate essential minerals for metabolic use, thus it is unlikely that zinc would bioaccumulate to potentially hazardous levels.

3.2.7.2 Estimation of Percent Ingested Onsite. The size of the areas used by the representative species, and hence their potential exposure to COCs, varies greatly. Generally, a species' home range is used to characterize the size of the area it uses on a regular basis (disregarding migration and dispersal). When home range information for a species was not available, population density values were used to estimate the area used by the species. This information, combined with the extent of the potentially contaminated sites, can be used to estimate the percent of dietary intake that a species gets from the sites.

TABLE 3-4. BIOCONCENTRATION FACTORS FOR SELECTED ORGANIC COMPOUNDS IN WATER

CHEMICAL	Log K _{ow}	BCF
DRPH	5.30	6,238
Toluene	2.69	65
PCB - Aroclor 1254	6.94	111,000
Xylene	3.16	149

Note: BCF calculated from Log K_{ow} according to the following equation:
 $\text{Log BCF} = 0.76 \text{ Log K}_{\text{ow}} - 0.23$ (Veith et al. 1979 in Spacie and Hamelink 1985)
K_{ow} = octanol/water partition coefficient

This estimate is referred to as the "percent of dietary intake at sites" value in the exposure estimate equation. The IS value is represented by the ratio of the total area of the sites (3.9 ha or 9.6 acres) to the reported home range size (or converted population density values) for the representative species. The representative species are most likely to be at Point Barrow during, or directly after, the breeding season, when many species become territorial. These territories represent the area used by the species. The densities of the population may provide estimates of the size of the territories and are used as substitute values when home range information is unavailable. This presents an added degree of uncertainty (see Section 3.5.3). If the home range (or converted population density value) is less than the total areal extent of the sites (3.9 ha), the maximum value for IS is 1.0 because it is possible that a species could meet all its dietary intake needs within the potentially contaminated areas. The IS values for the representative bird and mammal species are given below. Note that these are conservative estimates because the 3.9 ha size assumes that the contaminated sites are the only areas used. Obviously, the species would use the suitable areas between the potentially contaminated sites, resulting in lower potential exposure to COCs than if the species restricted its location to contaminated sites only.

Birds. Lapland longspur. IS = 0.5; Derksen et al. (1981) report a breeding density of 38.6 birds/km². This corresponds to about 1 bird/2.6 ha. Potentially, the longspur could meet all of its dietary demands within the potentially contaminated sites. Nevertheless, an IS value of 0.5 is used because the longspur prefers drier upland habitat and shrublike vegetation over the wetter areas and unvegetated gravel pads where the majority of contaminant pathways occur.

Brant. IS = 0.20; density of breeding pairs reported by Derksen et al. (1981) is 5.0 birds/km². At this density of 1 brant/20 ha, the total extent of the potentially contaminated sites is about 20 percent of the area a brant might use.

Glaucous gull. IS = 0.03; the density for the glaucous gull is reported by Derksen et al. (1981) as 0.8 birds/km². This density, about 1 gull/125 ha, yields an IS value of 0.03, indicating that the potentially contaminated sites are about three percent of the area the glaucous gull uses.

Pectoral sandpiper. IS = 0.87; the density of the pectoral sandpiper along the Arctic Coastal Plain is reported by Derksen et al. (1981) as 22.4 birds/km². This density equates to one sandpiper/4.5 ha, and a corresponding IS value of 0.87, which indicates that the potentially contaminated sites are about 87 percent of the area the sandpiper uses.

Spectacled eider. IS = 0.01; Derksen et al. (1981) report an average population density of 0.32 birds/km² for the spectacled eider. The resulting density of 1 bird/312.5 ha in 1981 is currently too high considering the decline in the species' population. The resulting IS value of 0.01 may result in an overestimation of potential exposure, but an overestimation may be considered acceptable in the evaluation of a sensitive species.

Mammals. Brown lemming. IS = 0.5; the lemming's home range is reported as 0.5 ha (Nowak 1991). It is possible that several lemmings may consume all their dietary needs within the bounds of a site. The lemming is not likely, however, to use the wetter sites (which constitute a large portion of the total extent of the sites) where the majority of the contaminant pathways are located. Also, the potentially contaminated sites are mostly gravel pads that have been constructed for development purposes, support little or no vegetation, and offer a poor matrix for the lemming to use for burrowing. For these reasons, the IS used for the brown lemming is 0.5 rather than 1.0.

Arctic fox. IS = 0.01; the home range of the fox is extremely variable. Eberhardt et al. (1982) report a home range of 3.7 to 20.8 km² (370 to 2,080 ha) for juvenile and adult arctic foxes, respectively. Using the lower end of the reported range (370 ha), results in an IS value of 0.01.

Caribou. IS = 0.01; caribou are highly mobile, covering large distances during their movements to and from calving grounds and in their constant search for suitable forage. They may range over thousands of kilometers a year, and as a result there is no accurate estimate of their home range. Based on knowledge of the caribou's habits and professional judgement, a very conservative IS value of 0.01 is used for the caribou.

3.2.7.3 Exposure Assessment for Representative Species of Birds. In this section the methods for quantifying exposures to the selected representative species of birds are presented.

In order to estimate exposures of the representative species of birds, life history information was compiled for the selected species. This information includes: occurrence at the DEW Line sites, habitat, average body weight, estimated food intake rate, estimated water intake rate, diet composition, and home range and/or population density.

Plant uptake of contaminants has been quantified for use in the exposure estimations for herbivores (bird and mammal species). Herbivores are potentially exposed to contamination directly from ingestion of soil and water intake as well as through their diet. The dietary plant component (CF in the exposure estimate equation) is calculated by multiplying the contaminant's

soil concentration by the BCF, B_v . B_v is defined as the ratio of the concentration in aboveground parts of a plant (mg of compound/kg of dry plant) to the concentration in soil (mg of compound/kg of dry soil). The B_v can be used to predict the level of a potential contaminant taken up by a plant, and this information can then be used to assess the potential transport of the contaminant in the trophic web.

The uptake of metals by plants is quantified using the B_v values in Baes et al. (1984). These values represent potential uptake to the vegetative portions of the plant. The approach for organic chemicals is basically the same, except that the B_v s for organic chemicals are derived using a regression equation (Travis and Arms 1988). The equation is:

$$\log B_v = 1.588 - 0.578 (\log K_{ow})$$

where:

$$B_v = \text{the BCF (unitless) and}$$

$$K_{ow} = \text{the octanol-water partition coefficient of the chemical (mol/m}^3 \text{ / mol/m}^3\text{)}.$$

In order to calculate the potential uptake of DRPH by plants, the K_{ow} of diesel fuel was estimated. The estimation of the K_{ow} was conducted using equation 2-3 in Lyman et al. (1982):

$$\log S = -0.922 \log K_{ow} + 4.184$$

where:

$$S = \text{solubility (mg/L) and}$$

$$K_{ow} = \text{octanol/water partition coefficient (mol/m}^3 \text{ / mol/m}^3\text{)}.$$

This equation estimates the solubility of an organic chemical in water. It may also be manipulated arithmetically to calculate the $\log K_{ow}$ based on the known solubility:

$$\log K_{ow} = \frac{\log S - 4.184}{-0.922}$$

The solubility of diesel fuel (0.2 mg/L) (Custance et al. 1992) was used to calculate the $\log K_{ow}$ of diesel fuel. The $\log K_{ow}$ is calculated to be 5.3.

Life history information for the Lapland longspur, brant, glaucous gull, pectoral sandpiper, and spectacled eider (although the spectacled eider is a threatened species, it is presented with the other avian species) is presented in Tables 3-5 through 3-9.

Information is not available on the daily food intake rate (grams/day) and water intake rate (liters/day) for the representative bird species in the arctic habitat. Therefore, this information was estimated using regression equations associated with body weight (Nagy 1987 for food intake rates; Calder and Braun 1983 for water intake rates). The severity of the arctic climate may impose higher metabolic demands on animals. As a result, the food and water intake rates should be considered estimates only, and their uncertainty should be kept in mind. The food intake rate was estimated using Nagy's (1987) equations:

TABLE 3-5. LIFE HISTORY INFORMATION FOR THE LAPLAND LONGSPUR, *Calcarius lapponicus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Seasonal breeder at arctic coastal radar installations	Dominant breeding passerine	U.S. Air Force 1993
Habitat	Breeds on arctic coastal tundra		Scott 1983
Body Weight	27.3 g (0.027 kg)	Mean of 68 specimens	Dunning 1984
Food Intake Rate	6.5 g/day dry matter	FI = 0.141 (BWkg) ^{0.850}	Nagy 1987
Water Intake Rate	0.005 liters/day	WI = 0.059 (BWkg) ^{0.67}	Calder and Braun 1983
Diet Composition	During breeding (June and July): insects (crane flies); pre- and post-breeding (May and August): seeds (grasses); average 25 percent vegetation in diet	Passerine member of insectivorous foraging guild which includes shorebirds	Custer and Pitelka 1978
Population Density	38.6/km ²	Varies with changing predation pressures	Derksen et al. 1981

TABLE 3-6. LIFE HISTORY INFORMATION FOR THE BRANT, *Branta bernicla*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Seasonal breeder at arctic coastal radar installations	Breeding, migratory sp., subsistence sp.	U.S. Air Force 1993
Habitat	Breeds on Arctic Coastal Plain	Prefers low, barren, wet, coastal terrain	Palmer 1976
Body Weight	1,305 g (1.305 kg)	Mean of 791 specimens	Dunning 1984
Food Intake Rate	69.2 g/day dry matter	FI = 0.0582 (BWkg) ^{0.651}	Nagy 1987
Water Intake Rate	0.07 liters/day	WI = 0.059 (BWkg) ^{0.67}	Calder and Braun 1983
Diet Composition	Sedges, grasses; average 90 percent vegetation in diet	Some insects during breeding (June and July)	Palmer 1976
Population Density	5.0/km ²	Average from three coastal sites	Derksen et al. 1981

TABLE 3-7. LIFE HISTORY INFORMATION FOR THE GLAUCOUS GULL, *Larus hyperboreus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Seasonal breeder at arctic coastal radar installations	Relatively common along arctic coast	Woodward-Clyde 1993
Habitat	Coastal tundra, lakes, ponds, and marine environment	Breeds on arctic coast	Farrand 1983
Body Weight	1,445 g (1.445 kg)	Mean of 65 specimens	Dunning 1984
Food Intake Rate	74 g/day dry matter	FI = 0.0582 (BWkg) ^{0.651}	Nagy 1987
Water Intake Rate	0.08 liters/day	WI = 0.059 (BWkg) ^{0.67}	Calder and Braun 1983
Diet Composition	Small fish, birds, insects, crustaceans, mollusks, garbage; average 10 percent of vegetation in diet	Predatory scavenger	Martin et al. 1961
Population Density	0.8/km ²	Average from three coastal sites	Derksen et al. 1981

TABLE 3-8. LIFE HISTORY INFORMATION FOR THE PECTORAL SANDPIPER, *Calidris melanotos*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Seasonal breeder at arctic coastal radar installations	Abundant on Arctic Coastal Plain	Woodward-Clyde 1993
Habitat	Grassy margins of wet meadows, marshes, riparian areas, ponds	Nests hidden on well-drained grassy sites	Scott 1983; Martin et al. 1961
Body Weight	79 g (0.079 kg)	Mean of 35 specimens	Dunning 1984
Food Intake Rate	11.2 g/day dry matter	FI = 0.0582 (BWkg) ^{0.651}	Nagy 1987
Water Intake Rate	0.01 liter/day	WI = 0.059 (BWkg) ^{0.67}	Calder and Braun 1983
Diet Composition	Insects, mollusks, crustaceans, worms, vegetable debris; average 10 percent vegetation in diet	Craneflies are major diet component	Martin et al. 1961; Pitelka 1959
Population Density	22.4/km ²	Average from three coastal sites	Derksen et al. 1981

TABLE 3-9. LIFE HISTORY INFORMATION FOR THE SPECTACLED EIDER, *Somateria fischeri*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Potential seasonal breeder at all arctic coastal radar installations	Winter whereabouts unknown	Woodward-Clyde 1993; Alaska Biological Research 1994
Habitat	Marine when not breeding, nests on coastal tundra	Nests on islets in tundra ponds and lakes, as well as ashore	Palmer 1976
Body Weight	1,375 g (1.375 kg)	Mean of 32 specimens	Dunning 1984
Food Intake Rate	71.6 g/day dry matter	FI = 0.0582 (BWkg) ^{0.651}	Nagy 1987
Water Intake Rate	0.07 liters/day	WI = 0.059 (BWkg) ^{0.67}	Calder and Braun 1983
Diet Composition	75 percent insects, mollusks, crustaceans; average of 25 percent plant matter in diet	Mostly insects when they are abundant; June and July	Kistchinski and Flint 1974
Population Density	0.32/km ²	Average of three coastal sites	Derksen et al. 1981

Passerine birds (i.e., Lapland longspur):

$$FI \text{ (kg/day dry matter)} = 0.141 \times (\text{body weight in kilograms})^{0.850}$$

All other birds:

$$FI \text{ (kg/day dry matter)} = 0.0582 \times (\text{body weight in kilograms})^{0.651}$$

The water intake rate was estimated using the regression equation developed by Calder and Braun (1983):

All birds:

$$WI \text{ (liters/day)} = 0.059 \times (\text{body weight in kilograms})^{0.67}$$

As animals forage they may incidentally ingest soil and sediment particles. The average concentration of contaminants in soil/sediment can be multiplied by the amount of soil/sediment ingested to estimate the potential uptake of contaminants by this route. Soil intake rates have been reported for just a few wildlife species (Beyer et al. 1994). The soil ingestion rates for the representative species are extrapolated from Beyer et al. (1994) by using similar species with reported values. The percentages reported are of the total weight of dietary intake. Table 3-10 lists the representative and sensitive bird species, the species used as surrogates, and the estimated percentages of soil ingested in quantifying exposure to contaminants. Species that forage directly in the soil or sediment, such as the sandpiper or goose, show relatively high percentages of soil in their diet. The Lapland longspur does not have appropriate surrogate species with soil ingestion data. Although the longspur is in the same foraging guild as sandpipers (which incidentally ingest relatively large amounts of soil), the longspur takes insects from the soil surface or gleans its prey from vegetation (Custer and Pitelka 1978), thus minimizing its soil intake; the estimate of soil ingestion (less than two percent of diet by weight) reflects this. The glaucous gull ingests stones and sand as a mechanical addition (to aid in digestion) to its diet (Belopol'skii 1961) and this contributes to its soil/sediment intake. For those species without a suitable surrogate or whose soil ingestion rate is reported as less than two percent, a value of two percent of dietary intake (by weight) was used to calculate the exposure estimates.

3.2.7.4 Exposure Assessment for Representative Species of Mammals. This section assesses exposure to contaminants for the selected representative species of mammals. Table 3-11 (brown lemming), Table 3-12 (arctic fox), and Table 3-13 (caribou) present life history data that are used to calculate exposure estimates for the representative mammalian species. Home range and/or population density has been listed for the representative mammal species, depending on appropriateness and availability.

Information on daily food intake rates for the arctic fox and caribou was not available. The rates have been estimated using regression equations associated with average body weights and metabolic rates (Nagy 1987). The food intake rates for the fox and caribou were estimated using the following equations, developed for placental mammals in general and for herbivorous mammals, respectively (Nagy 1987).

TABLE 3-10. SOIL INGESTION ESTIMATES FOR REPRESENTATIVE AND SENSITIVE BIRD SPECIES

REPRESENTATIVE SPECIES	SURROGATE SPECIES	ESTIMATED PERCENT OF SOIL IN DIET	ESTIMATED SOIL IN DIET (g/day)
Lapland Longspur	No suitable surrogate	<2.0	0.1
Brant	Canada Goose	8.2	5.7
Glaucous Gull	Siberian Glaucous Gull ^a	7.6	5.6
Pectoral Sandpiper	Four Sandpiper Species (average)	18.1	2.0
Spectacled Eider	Canada Goose	8.2	5.9

Source: Beyer et al. 1994

^a Data from Belopol'skii 1961.

TABLE 3-11. LIFE HISTORY INFORMATION FOR THE BROWN LEMMING, *Lemmus trimucronatus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Resident at all arctic coastal radar installations	Dominant small mammal	U.S. Air Force 1993
Habitat	Tundra and alpine meadows	Nests above ground in winter, below in summer	Burt and Grossenheider 1976
Body Weight	55 g (0.055 kg)		Chappell 1980
Food Intake Rate	24 to 45 g/day dry matter	Has low assimilation efficiencies (31 - 36 percent), variation related to seasons	Chappell 1980
Water Intake Rate	0.007 liters/day	$WI = 0.099 (BWkg)^{0.90}$	Calder and Braun 1983
Diet Composition	Sedges, grasses, lichens, roots, leaves, bark, berries		Nowak 1991
Home Range Size (AVG)	0.5 ha (females) 1.0 ha (males)	0.5 ha used in assessment	Nowak 1991
Population Density	0 to 325/ha	Populations have large fluctuations on a three to five year cycle; currently populations are low	Nowak 1991; Snyder-Conn 1994

TABLE 3-12. LIFE HISTORY INFORMATION FOR THE ARCTIC FOX, *Alopex lagopus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Resident at all arctic coastal radar installations	Ubiquitous	U.S. Air Force 1993
Habitat	Tundra and coastal plain	Dens in sandy mounds >1 m high	Chesemore 1967
Body Weight	4950 g (4.95 kg)		Burt and Grossenheider 1976
Food Intake Rate	256 g/day dry matter	FI = 0.0687 (BWkg) ^{0.822}	Nagy 1987
Water Intake Rate	0.42 liters/day	WI = 0.099 (BWkg) ^{0.90}	Calder and Braun 1983
Diet Composition	Brown lemming (summer), nesting birds, carrion, seal pups, non-food items	Brown lemming in >85 percent of all scats, n=224	Chesemore 1967; Nowak 1991
Home Range Size (AVG)	20.8 km ² adult 3.7 km ² juvenile (<1 yr)	Adult range used in assessment	Eberhardt et al. 1982

TABLE 3-13. LIFE HISTORY INFORMATION FOR THE BARREN-GROUND CARIBOU, *Rangifer tarandus*

PARAMETER	VALUE	NOTES	REFERENCE
Occurrence at DEW Line Sites	Seasonal, at or near all arctic coastal radar installations during migrations	Areas near some installations used for calving	U.S. Air Force 1993
Habitat	Tundra in summer, open coniferous forest in winter	Varies, related to migration	Burt and Grossenheider 1976
Body Weight	95,500 g (95.5 kg)	Mean for adults	Nowak 1991
Food Intake Rate	2400 g/day (2.4 kg) dry matter	FI = 0.0875 (BWkg) ^{0.727}	Nagy 1987
Water Intake Rate	6.0 liters/day	WI = 0.099 (BWkg) ^{0.90}	Calder and Braun 1983
Diet Composition	Willows, sedges, cottongrass, lichens	Selection based on plant phenology	Skogland 1980; White and Trudell 1980
Population Density	1.41 km ² 0.31 km ² 4.53 km ²	Undisturbed calving area within 1 km of road within 5-6 km of road	Cameron et al. 1992

arctic fox: using equation for placental mammals in general
 $FI \text{ (kg/day dry matter)} = 0.0687 \times (\text{body weight in kilograms})^{0.822}$

caribou: using equation for mammalian herbivores
 $FI \text{ (kg/day dry matter)} = 0.0875 \times (\text{body weight in kilograms})^{0.727}$

Because of very low assimilation efficiencies, the low nutrient content of winter forage, and the high metabolic demands in arctic habitats (Chappell 1980), the equation for food intake rate significantly underestimates the rate for the brown lemming. A more appropriate rate for the brown lemming of 45 g/day is reported by Chappell (1980) (using the highest value in the reported range of 24-45 g/day).

The rates for water intake of the representative mammals were estimated using the equation generated by Calder and Braun (1983) because of the unavailability of species-specific information in the literature. The equation is:

$$WI \text{ (liters/day)} = 0.099 \times (\text{body weight in kilograms})^{0.90}$$

Incidental soil intake was evaluated for mammals in the same manner as for birds (Section 3.2.7.3). Table 3-14 shows the percent of soil ingested for the representative mammal species.

3.3 ECOLOGICAL TOXICITY ASSESSMENT

This section presents toxicity information for each COC in surface water and soil/sediment. The COCs identified in surface water are iron and GRPH (Section 3.1.1). The COCs in soil/sediment are DRPH, GRPH, toluene, xylenes, PCBs (Aroclor 1254), lead, and zinc (Section 3.1.2). Sections 3.3.1 through 3.3.7 discuss the toxicity of all COCs to the receptor groups. Section 3.3.8 presents the derivation of TRVs used for this ERA.

3.3.1 Petroleum Hydrocarbons

Petroleum hydrocarbons were identified as COCs in surface water (GRPH) and soil/sediment (DRPH and GRPH). This section is a discussion of the chemical compositions of DRPH and GRPH and the toxicity of these petroleum mixtures.

TABLE 3-14. SOIL INGESTION ESTIMATES FOR REPRESENTATIVE MAMMAL SPECIES

REPRESENTATIVE SPECIES	SURROGATE SPECIES	ESTIMATED PERCENT OF SOIL IN DIET	ESTIMATED SOIL IN DIET (g/day)
Brown Lemming	White-tailed Prairie Dog	2.7	1.2
Arctic Fox	Red Fox	2.8	7.2
Caribou	Elk	<2.0	48

Source: Beyer et al. 1994

Crude petroleum contains thousands of different chemical compounds. Gasoline and diesel fuel are refined petroleum products. The composition of gasoline and diesel fuel depends on not only the origin of the crude oil from which the gasoline is derived, but also the process technique and the blending scheme (Von Burg 1993). Once gasoline or diesel fuel is released to the environment, weathering and volatilization further alter its composition.

Gasoline is a complex, highly variable mixture of petroleum hydrocarbons containing three to 21 carbon atoms; however, compounds with four to 12 carbon atoms predominate. Gasoline is detected with the petroleum hydrocarbon analysis as GRPH. The following chemical classes are detected as GRPH: paraffins (straight-chained alkanes), olefins (straight-chained alkenes), naphthenes (cycloalkanes and alkenes), and aromatic hydrocarbons (alkylbenzenes and polycyclic aromatic hydrocarbons [PAHs]) (Von Burg 1993). Although GRPH are generally in the range of four to 12 carbon atoms, the laboratory that conducted the analyses for Point Barrow detected GRPH with six to nine carbon atoms. As many as 140 compounds have been identified as constituents of gasoline; however, a small number of constituents such as benzene drive the toxicity. Diesel fuel is also a complex, variable mixture of the same classes of compounds containing six to 21 carbon atoms. Diesel fuel is detected with the petroleum hydrocarbon analysis as DRPH. The laboratory that analyzed samples for Point Barrow detected DRPH with 10 to 24 carbon atoms. As many as 45 compounds have been identified as constituents of diesel fuel (Von Burg 1993).

Table 3-15 presents the chemical classes and weight percent for GRPH and DRPH. Generally, gasoline contains more aromatic compounds and simple-chained alkanes, whereas diesel fuel is characterized by cycloparaffins (or cycloalkanes). Both gasoline and diesel fuel will be affected by the environment. Weathering will change the chemical composition of petroleum, and concentrations of aromatic compounds such as benzene will decrease as a result of volatilization. Available toxicity test data have been derived from pure, fresh product, and therefore the applicability to the weathered product encountered at Point Barrow is uncertain. Gasoline is the most studied of the petroleum products; however, most data are based on inhalation studies. Gasoline was classified by EPA (1992c) as a Group C (possible human) carcinogen, whereas diesel oil was classified as Group D (not classifiable as to human carcinogenicity). Presumably, this classification of gasoline is due to benzene, which, under the conditions of environmental exposure, would volatilize more rapidly than any other constituent. Physical-chemical data from the literature indicates that total petroleum hydrocarbon (TPH) in soil would reflect all constituents with eventual loss of aromatic (e.g., BTEX) components first, lighter alkanes second, lighter PAHs third, followed by naphthalenes. For an old diesel or petroleum spill, petroleum hydrocarbon measurements may reflect predominantly trace amounts of high molecular-weight PAHs or higher molecular-weight and branched alkanes [Massachusetts Department of Environmental Protection (MDEP) 1993].

For the purposes of ranking the toxicity of GRPH and DRPH, it was assumed that BTEX and lighter-weight alkanes have been significantly weathered from exposure to the arctic environment, and that toxicity is more dependent upon noncarcinogenic endpoints associated with alkanes, alkenes, and cycloalkanes. The toxicity of DRPH is also associated with the PAH content. At Point Barrow however, only two PAHs were detected: naphthalene (detected in surface water and soil/sediment) and 2-methylnaphthalene (detected in soil/sediment), chemicals considered

TABLE 3-15. CHEMICAL CLASSES OF GRPH AND DRPH

CHEMICAL CLASS	WEIGHT PERCENT ^a
GRPH^b	
Normal paraffins (n-alkanes)	19.3-38.4 (28.8)
Isoparaffins (isoalkanes)	11.5-50.3 (30.9)
Naphthenes (cycloparaffins or cycloalkanes)	1.0-2.8 (1.9)
Aromatics (e.g., benzene, toluene, pyrene)	9.7-54.7 (32.2)
DRPH^c	
Normal paraffins (n-alkanes)	5.6
Isoparaffins (isoalkanes)	11.1
Naphthenes (cycloparaffins or cycloalkanes)	46.3
Aromatics (e.g., benzene, toluene, pyrene)	33.3
Nitrogen, sulfur and oxygen compounds	3.7

^a Average shown in parentheses.

^b Heath et al. 1993.

^c Weeks et al. 1988.

to be noncarcinogenic. MDEP (1993) reviewed the noncarcinogenic toxicological endpoints in laboratory animals for diesel fuel and gasoline, and determined that diesel fuel was an order of magnitude more toxic than gasoline, although other sources indicate the toxicity of alkanes and cycloalkanes is similar (Armstrong Laboratory 1994; Sax and Lewis 1989). A review of the Point Barrow data indicates that DRPH are present at higher concentrations than GRPH in soil/sediment. Specifically, average concentrations of DRPH in soil/sediment were approximately three times higher than average concentrations of GRPH in soil/sediment. As a result, based on the MDEP review and the chemical data reported for the Point Barrow soil/sediment samples, the evaluation of DRPH is used to conservatively represent ecological risks from petroleum hydrocarbon contamination in soil/sediment (i.e., including GRPH and other constituent chemicals such as naphthalene, 2-methylnaphthalene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene).

The following sections summarize the toxicity of diesel fuel (DRPH) and gasoline (GRPH) to plants, aquatic organisms, birds, and mammals. The compounds are grouped together in the following discussions because the constituents that drive the toxicity of DRPH and GRPH are often the same.

3.3.1.1 Plants. Petroleum released to the aquatic environment may be toxic to aquatic plants. Toxicity tests have shown that the water-soluble components of petroleum are toxic to an algal species (*Chlorella vulgaris*) (Kauss and Hutchinson 1975); however, in this specific study, the toxicity was short term. The algal community recovered after a "lag phase". It was theorized (Kauss and Hutchinson 1975) that this trend was due to the loss of highly volatile fractions from the testing chamber over time. Exposure to water extracts of No. 2 Fuel Oil depressed algal biomass in communities and resulted in blue-green algal dominance and decreased diatom occurrence (Bott and Rogenmuser 1978). No data was available concerning plant exposure to GRPH, but the data for DRPH may be used to evaluate the exposure to GRPH.

3.3.1.2 Aquatic Organisms. Moles et al. (1979) tested the acute toxicity of Prudhoe Bay crude oil to several Alaskan freshwater and anadromous fish. Salmonids were the most sensitive species tested, and demonstrated median tolerance limits (the concentration at which one half the organisms survive in 96 hours, same as LC_{50} [lethal concentration for 50 percent of the organisms]) ranging from 2.7 to 4.4 mg/L. The three-spined stickleback, *Gasterosteus aculeatus*, was more tolerant, with an LC_{50} of 10.4 mg/L. Klein and Jenkins (1983) studied the toxicity of the water-soluble fraction of jet fuel to fish. Growth of fry was retarded by 1.5 mg/L of the water-soluble fraction of JP-8 (jet fuel with de-icer). In a study conducted by Hedtke and Puglisi (1982), the method of introducing the oil to the test chamber was an important variable driving toxicity. Emulsified oils were substantially more toxic than either floating oils or the water-soluble fraction. The 96-hour LC_{50} for fathead minnows (*Pimephales promelas*) exposed to the emulsion of No. 2 jet fuel was 38.6 mg/L (concentration used to calculate the TRV for GRPH and DRPH). Because no toxicity data was available for GRPH and fish, the jet fuel data was used to evaluate the nine-spined stickleback's exposure to GRPH.

Aquatic organisms other than fish may also be exposed to diesel fuel in the environment. Studies have shown that freshwater arctic zooplankton may be more sensitive to oil pollution than any other arctic freshwater organisms (O'Brien 1978). Geiger and Buikema (1981) estimated an LC_{20} (concentration lethal to 20 percent of the test organisms) of No. 2 Fuel oil to *Daphnia pulex* of 5.6 mg/L (concentration used to calculate TRV). This data is used to evaluate *Daphnia* exposure to GRPH.

3.3.1.3 Birds. Petroleum hydrocarbons in the environment may affect bird reproduction. External application of No. 2 Fuel oil to mallard (*Anas platyrhynchos*) and common eider (*Somateria mollissima*) eggs significantly increased embryo mortality (Albers 1977; Szaro and Albers 1977). Mallard eggs were treated with 1, 5, 10, 20, and 50 μ l of fuel oil. Ingestion of crude oil by mallards at a concentration of five percent by weight in the diet resulted in depressed growth (Szaro et al. 1978). Hartung (1964) demonstrated a decrease in weight gain in mallards during the first 10 days after receiving 6,000 mg/kg No. 2 Fuel Oil (concentration used to calculate the DRPH TRV); however, after 34 days, there was no difference between treatment groups and the controls. No toxicity data was available for avian exposure to GRPH specifically, but the evaluation of DRPH and a comparison of avian and mammalian GRPH toxicities (presented in Section 3.4.3, Risk Characterization) was used to assess avian GRPH exposure.

3.3.1.4 Mammals. The toxicity of DRPH and GRPH to the representative mammals can be evaluated using the toxicity to rats. Diesel fuel is relatively nontoxic to rats based on an acute

oral LD₅₀ (lethal dose for 50 percent of the organisms) of 7,380 mg/kg (Beck et al. 1982) (dose used to calculate TRV). Based on subchronic renal studies using rats exposed to unleaded gasoline, a NOAEL of 500 mg/kg was reported (ATSDR 1993b). This dose was used to calculate the GRPH TRV for mammals.

3.3.2 Toluene

Toluene, identified as a COC in soil/sediment at the Point Barrow sites, is an alkylbenzene and a common constituent of petroleum products (ATSDR 1993a). Toluene toxicity in animals is commonly manifest as depression of the central nervous system (Klaasen et al. 1986). A summary of the relevant toxicity information is presented below.

3.3.2.1 Plants. No information was available concerning the toxicity of toluene to plants. A qualitative discussion of the toxicity of VOCs to plants is presented in Section 3.4.1, Risk Characterization.

3.3.2.2 Aquatic Organisms. No aquatic toxicity information is presented because toluene was not identified as a COC in surface water.

3.3.2.3 Birds. No toxicity information was available for toluene toxicity to birds. A qualitative discussion and comparison of mammalian and avian toxicity values is presented in Section 3.4.3, Risk Characterization.

3.3.2.4 Mammals. Nawrot and Staples (1979 in Opresko et al. 1994) reported a chronic reproductive LOAEL for laboratory mice orally exposed to toluene at 259.8 mg/kg. Using an uncertainty factor (UF) of 0.1, Opresko et al. (1994) convert the LOAEL to a chronic NOAEL for mice of 25.98 mg/kg. This is the value used to calculate the toluene TRV for mammals.

3.3.3 Xylene

Xylene is a COC in soil/sediment at the Point Barrow sites. It is an alkylbenzene and a common constituent of petroleum products (ATSDR 1993a). Most toxicity information in the literature relates to the inhalation of xylene. A summary of the relevant information is presented below.

3.3.3.1 Plants. In a study of the green algae, *Selenastrum capricornutum*, xylene decreased growth at concentrations of 72,000 µg/L (Gaur 1988 in AQUIRE 1990).

3.3.3.2 Aquatic Organisms. No aquatic toxicity information is presented because xylene was not identified as a COC in surface water.

3.3.3.3 Birds. When mallard eggs were immersed in xylene (one percent and ten percent) for 30 seconds, there was no significant effect on embryonic weight and length when compared to controls (Hoffman and Eastin 1981 in HSDB 1994). Japanese quail (*Coturnix japonica*) fed xylene demonstrated no sign of toxicity up to 5,000 parts per million (ppm) (USFWS 1986). The LC₅₀ was >20,000 ppm (USFWS 1986). Hill and Camardese (1986) report a

maximum dietary exposure level for Japanese quail of 608 mg/kg total xylenes (dose used to calculate TRV).

3.3.3.4 Mammals. Ingestion of xylene in mammals may cause prenatal mortality, growth inhibition, and malformations, primarily cleft palate. The LD₅₀ for ingestion of xylene (rat) was reported as 4,300 mg/kg (Clayton and Clayton 1981) (dose used to calculate TRV).

3.3.4 Polychlorinated Biphenyls

PCBs are organic compounds manufactured by chlorinating biphenyl molecules (Eisler 1986). Depending upon the average degree of chlorination, the PCBs are grouped into seven Aroclor groups (Aroclor is the trade name of PCBs produced in the U.S.), each with varying toxicity. The four digit number following the Aroclor name usually begins with 12 (representing biphenyl), and ends with two digits that represent the percentage of chlorine by weight. For example, Aroclor 1254 is 54 percent chlorine by weight, while Aroclor 1260 is 60 percent chlorine by weight. Usually the more chlorinated Aroclors (e.g., 1254 and 1260) are more toxic than the lesser chlorinated Aroclors (e.g., 1232 and 1242). The PCBs identified as COCs in soil/sediment at the Point Barrow installation were Aroclor 1254. PCBs are very stable in the environment, slow to degrade and are bioaccumulative. The following sections summarize the toxicity of PCBs.

3.3.4.1 Plants. Very little toxicity information for plants is available in the literature. However, PCBs may inhibit photosynthesis and cell motility in phytoplankton (Eisler 1986). In addition, aquatic plants may provide a route of exposure into the aquatic food chain. An increase (five times) in somatic mutations was noted in terrestrial plants growing on sediments containing mean PCB residues of 26 mg/kg (predominantly Aroclor 1254) (Eisler 1986).

3.3.4.2 Aquatic Organisms. No aquatic toxicity information is presented because PCBs were not identified as a COC in surface water.

3.3.4.3 Birds. PCBs are expected to disrupt patterns of growth, reproduction, metabolism, and behavior in sensitive avian species (Eisler 1986). Mourning doves (*Zenaidura macroura carolinensis*) that were fed 10 and 40 ppm Aroclor 1254 for six weeks exhibited abnormal courtship behavior and reproductive effort. The researchers suggested that the disrupted reproductive behavior was due to reduced hormone levels (Tori and Peterle 1983 in Eisler 1986). No reproductive effects were observed in mallards (*Anas platyrhynchos*) exposed to 150 ppm (mg/kg feed) Aroclor 1252 in the diet for 12 weeks during egg laying (Haseltine and Prouty 1980), or in mallards exposed to 25 ppm Aroclor 1254 in the diet for at least a month before egg laying (Custer and Heinz 1980 in Eisler 1986). A chronic reproductive LOAEL for ring-necked pheasants of 1.8 mg/kg was reported by Heath et al. (1972), and this dose was used to calculate the TRV.

3.3.4.4 Mammals. Reproductive toxicity following chronic or subchronic exposures appears to be the most sensitive toxic endpoint of PCBs exposure in mammals. Mink (*Mustela vison*) are particularly susceptible to PCBs' reproductive effects. Mink fed contaminated beef (Aroclor 1254) developed reproductive complications at dietary residue levels as low as 0.64 ppm (Platanow and Karstad 1973). A dietary level LC₅₀ of 6.7 ppm was reported for an exposure

period of nine months for Aroclor 1254 (Ringer 1983). Other species may be less sensitive to PCBs' toxic effects. Averlich and Ringer (1977 in Opresko et al. 1994) report a NOAEL dose of Aroclor 1254 for mink of 0.137 mg/kg. This dose was used to calculate the carnivore TRV (used for the arctic fox). White-footed mice (*Peromyscus leucopus*) exposed to PCBs at a concentration of 10 ppm (1.35 mg/kg Aroclor 1254 is the LOAEL dose used to calculate the herbivore TRV) in the diet through the second generation exhibited poor reproductive success, growth, and development of organs, but no increased mortality [Linzey 1988 in Opresko et al. 1994]).

3.3.5 Iron

Iron was identified as a COC in surface water at the Point Barrow sites. Iron is an essential trace element required by both plants and animals. It plays an important role in the transport of oxygen in animals. Available information for iron is summarized below.

3.3.5.1 Plants. In a study conducted by Foy et al. (1978 in EPA 1985), concentrations of 100 to 500 ppm soluble iron in soil were toxic to rice.

3.3.5.2 Aquatic Organisms. Iron may be a threat in aquatic environments in the form of precipitates that can destroy habitat, coat gills, and inhibit oxygen uptake. The EPA uses 1,000 µg/L as the chronic AWQC protective of aquatic life (dose used to calculate TRV) (EPA 1986c). Doudoroff and Katz (1953 in EPA 1976) found iron concentrations of 1,000 to 2,000 µg/L toxic to northern pike (*Esox lucius*) and trout (species not reported).

3.3.5.3 Birds. There are few studies available that address the toxicity of iron to species of wild birds. There were no adverse effects produced in turkeys at concentrations of 440 ppm (Woerpel and Balloun 1964 in NAS 1980). NAS (1980) recommends that the maximum tolerable level of dietary iron of 1,000 ppm be used for poultry. The 1,000 ppm dose converts to 70.0 mg/kg for a maximum tolerable dietary level for a chicken (dose used to calculate TRV).

3.3.5.4 Mammals. At high concentrations, iron is toxic to livestock and interferes with phosphorus metabolism (NAS 1974 in EPA 1976). Cattle fed 477 µg/g iron demonstrated a slight decrease in weight gain; concentrations of 1,677 µg/g of iron produced a significant decline in growth rate (EPA 1985). Shanas and Boyd (1969 in NAS 1980) report an acute LD₅₀ dose of 1,000 mg/kg for the rat (dose used to calculate TRV for brown lemming and arctic fox). The maximum tolerable dietary level of 500 ppm of iron (converted to 20 mg/kg) for sheep is used to calculate the TRV for caribou (NAS 1980).

3.3.6 Lead

Lead was identified as a COC in soil/sediment at the Point Barrow sites. Lead is a trace element naturally found in environmental media (e.g., soil, water, etc.); however, it is neither essential nor beneficial to living organisms (Eisler 1988). Available information for lead is summarized below.

3.3.6.1 Plants. Lead inhibits plant growth and reduces photosynthesis, mitosis, and water absorption (Eisler 1988). Concentrations of 500 mg/kg in soils were found to result in

reduced pollen germination in several weed species, but the same study found that 46 mg/kg lead concentrations in soil did not have adverse effects on pollen germination (USACOE 1991).

3.3.6.2 Aquatic Organisms. No toxicity information is presented for aquatic organisms because lead was not identified as a COC in surface water.

3.3.6.3 Birds. The bulk of the toxicity information in the literature regarding avian exposure to lead concerns waterfowl that have ingested spent lead shot and died. There is, however, limited dose-response information available for some species. Mautino and Bell (1987) reported neurological effects in mallards that had ingested and absorbed lead shot for a total intake of 423.8 mg/kg body weight. Young American kestrels (*Falco sparverius*) (one day old) that ingested 125 and 625 mg/kg body weight of lead showed significantly depressed growth and hematocrit values (Hoffman et al. 1985). Based on a review of several studies, 12.0 mg/kg (USACOE 1991) is the highest chronic NOAEL lead dose for many species of birds. This is the dose used to calculate the TRV.

3.3.6.4 Mammals. Lead may affect the survival, growth, development, and metabolism of animal species. Rats are affected by 5 to 108 mg/kg body weight (acute oral dose); dogs by 0.32 mg/kg body weight daily (chronic oral dose); and horses by chronic dietary concentrations of 1.7 mg/kg (Eisler 1988). Azar et al. (1973 in Opresko et al. 1994) report an oral dose of 8.0 mg/kg-bw/day as a chronic NOAEL for laboratory rats (dose used to calculate TRV for brown lemming and arctic fox). Fick et al. (1976 in NAS 1980) report a chronic NOAEL for sheep of 10 ppm (converted to 0.4 mg/kg) in diet. This value is used to calculate the TRV for caribou.

3.3.7 Zinc

Zinc was identified as a COC in soil/sediment at the Point Barrow sites. Zinc is considered to be an essential nutrient for animals (Eisler 1993), and is necessary for plant growth. Deficiencies of zinc in the diet may retard growth in animals (Eisler 1993). Toxicity information for zinc, and the groups of representative species, is presented below.

3.3.7.1 Plants. According to information presented in Eisler (1993), plants that are sensitive to zinc concentrations die when soil levels are in excess of 100 mg/kg or if plant tissue content exceeds 178 mg/kg. The amount of zinc absorbed from soil by plants is dependent upon soil-specific characteristics. USACOE (1991) report that several species of plants find average concentrations of zinc of 270 mg/kg in soil to be phytotoxic.

3.3.7.2 Aquatic Organisms. No toxicity information is presented for aquatic organisms because zinc was not identified as a COC in surface water.

3.3.7.3 Birds. When ducks were fed 2,500 to 3,000 mg/kg ration of zinc, or alternately force-fed zinc at 742 mg/kg body weight, survival was reduced (Eisler 1993). Chickens were more resistant to zinc exposure; 8,000 mg zinc/kg ration was lethal to chicks (Eisler 1993). Elevated levels of zinc (20 g zinc/kg ration) are given to poultry to induce molting and subsequently reduce egg deposition (Eisler 1993). A four-week study conducted by Roberson

and Schaible (1960 in NAS 1980) calculated a NOAEL of 1,000 ppm for one-day-old chicks. This value was used to calculate the avian TRV.

3.3.7.4 Mammals. According to Eisler (1993), zinc is relatively non-toxic to mammals (as might be expected for an essential trace element). There is a large range between normal dietary intakes and concentrations expected to cause harm. Adult male rats, when fed zinc at levels of 500 mg/kg diet, were adversely affected; spermatogenesis was arrested, and testes enlarged (Eisler 1993). Zinc concentrations of 6,820 mg zinc/kg ration suppressed rat growth and produced changes in the pancreas (Eisler 1993). A chronic NOAEL for laboratory rats of 160 mg/kg-bw/day is reported by Schlicker and Cox (1968 in Opresko et al. 1994). The TRVs for the brown lemming, arctic fox, and caribou are derived from this toxicity value.

3.3.8 Characterization of Effects

In this section toxicity information is presented for representative ecological receptors evaluated in the risk characterization of this report (Section 3.4). Potential impacts to aquatic receptors are evaluated by comparing exposure concentrations to TRVs. TRVs for the representative aquatic species are presented in Table 3-16. Potential impacts to terrestrial wildlife are evaluated for the representative species based on comparisons of estimated exposures to TRVs. Exposure to COCs for the representative terrestrial species is primarily through diet; which may include plants, fish, aquatic invertebrates, soils, and surface water. TRVs are derived for COCs in surface water and soil/sediment. TRVs for the representative and sensitive bird species are presented in Table 3-17, and for the representative mammal species in Table 3-18.

3.3.8.1 Toxicity Reference Values. TRVs are derived by selecting toxicity values from the literature and extrapolating to the species of concern. UFs and body scaling factors are used in the extrapolation process as described below.

- (1) The first step is to select an appropriate toxicity value from the scientific literature for each combination of chemical and representative or protected species. Test species most similar to the species of concern are preferred. A secondary emphasis is given to tests conducted over a significant portion of the animal's natural lifespan (i.e., chronic tests) when available.
- (2) The second step is to modify the toxicity value, if necessary, through application of UFs associated with the quality of toxicity data to derive a NOAEL (the highest concentration of a material in a toxicity test that has no statistically significant adverse effect on the exposed population of test organisms as compared with the next highest dose tested). If a chronic NOAEL or No Observed Effect Level (NOEL) is available, it is used with a UF of one (i.e., no adjustment) because these values have the lowest uncertainty. If chronic data are unavailable, acute or subchronic toxicity data are modified by UFs to extrapolate to chronic effects. Based on Harding Lawson Associates (1992), the following strategy was derived for UFs for extrapolating study results to chronic NOAELs: 10 for chronic lowest-observed effect level (LOEL) values, 10 for subchronic NOEL values, and 20 for

TABLE 3-16. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF AQUATIC ORGANISMS AT THE POINT BARROW INSTALLATION

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	CONCENTRATION $\mu\text{g/L}$	TEST SPECIES	NOAEL UF	INTERSPECIES UF	PROTECTED SPECIES UF	TRV $\mu\text{g/L}$	REFERENCE
GRPH*	nine-spined stickleback	LC ₅₀	38,600	fathead minnow	20	2	1	965	Hedike and Puglis 1982
	<i>Daphnia</i> spp.	LOAEL	5,600	<i>D. pulex</i>	20	1	1	280	Hedike and Puglis 1982
Iron	nine-spined stickleback	EPA chronic water quality criteria	1,000	all aquatic life	1	1	1	1,000	EPA 1986
	<i>Daphnia</i> spp.	EPA chronic water quality criteria	1,000	all aquatic life	1	1	1	1,000	EPA 1986

Toxicity information shown is for DRPH; no data available for GRPH.

TABLE 3-17. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE AND SENSITIVE SPECIES OF BIRDS AT THE POINT BARROW INSTALLATION

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
Iron	Lapland longspur	NOAEL; 28 day growth study	70.0	chicken	1	0.32	2	2	54.7	McGhee et al. 1965 in NAS 1980
	brant	NOAEL; 28 day growth study	70.0	chicken	1	1.18	2	2	14.8	McGhee et al. 1965 in NAS 1980
	glaucous gull	NOAEL; 28 day growth study	70.0	chicken	1	1.22	2	2	14.3	McGhee et al. 1965 in NAS 1980
	pectoral sandpiper	NOAEL; 28 day growth study	70.0	chicken	1	0.46	2	2	38.0	McGhee et al. 1965 in NAS 1980
	spectacled eider	NOAEL; 28 day growth study	70.0	chicken	1	1.20	2	2	14.6	McGhee et al. 1965 in NAS 1980
	Lapland longspur	chronic growth and reproduction NOAEL	12	all birds	1	na	na	2	6	USACOE 1991
Lead	brant	chronic growth and reproduction NOAEL	12	all birds	1	na	na	2	6	USACOE 1991
	glaucous gull	chronic growth and reproduction NOAEL	12	all birds	1	na	na	2	6	USACOE 1991
	pectoral sandpiper	chronic growth and reproduction NOAEL	12	all birds	1	na	na	2	6	USACOE 1991
	spectacled eider	chronic growth and reproduction NOAEL	12	all birds	1	na	na	2	6	USACOE 1991
Zinc	Lapland longspur	subchronic dietary NOAEL	175	chicken	10	0.32	2	2	14	Roberson and Schaible 1960 in NAS 1980
	brant	subchronic dietary NOAEL	175	chicken	10	1.18	2	2	3.7	Roberson and Schaible 1960 in NAS 1980
	glaucous gull	subchronic dietary NOAEL	175	chicken	10	1.22	2	2	3.6	Roberson and Schaible 1960 in NAS 1980

na Not applicable.

TABLE 3-17. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE AND SENSITIVE SPECIES OF BIRDS AT THE POINT BARROW INSTALLATION (CONTINUED)

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
Zinc (Continued)	pectoral sandpiper	subchronic dietary NOAEL	175	chicken	10	0.46	2	2	9.5	Roberson and Schaible 1960 in NAS 1980
	spectacled elder	subchronic dietary NOAEL	175	chicken	10	1.20	2	2	4	Roberson and Schaible 1960 in NAS 1980
DRPH	Lapland longspur	decreased weight gain LOAEL	6,000	mallard	10	0.29	2	2	517	Hartung 1964
	brant	decreased weight gain LOAEL	6,000	mallard	10	1.07	2	2	140	Hartung 1964
	glaucous gull	decreased weight gain LOAEL	6,000	mallard	10	1.10	2	2	136	Hartung 1964
	pectoral sandpiper	decreased weight gain LOAEL	6,000	mallard	10	0.42	2	2	357	Hartung 1964
	spectacled elder	decreased weight gain LOAEL	6,000	mallard	10	1.08	2	2	139	Hartung 1964
GRPH	No avian data available for GRPH; refer to DRPH data as surrogate toxicity information.									
Toluene	No avian data available for toluene; see discussion in Section 3.4.3, Potential Risks to Representative Species of Birds									
Xylenes (Total)	Lapland longspur	Maximum dietary exposure	608	Japanese quail	10	0.60	2	2	25	Hill and Camardese 1986
	brant	Maximum dietary exposure	608	Japanese quail	10	2.16	2	2	7	Hill and Camardese 1986
	glaucous gull	Maximum dietary exposure	608	Japanese quail	10	2.23	2	2	7	Hill and Camardese 1986
	pectoral sandpiper	Maximum dietary exposure	608	Japanese quail	10	0.85	2	2	18	Hill and Camardese 1986
	spectacled elder	Maximum dietary exposure	608	Japanese quail	10	2.39	2	2	6	Hill and Camardese 1986

na Not applicable.

TABLE 3-17. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE AND SENSITIVE SPECIES OF BIRDS AT THE POINT BARROW INSTALLATION (CONTINUED)

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
PCBs	Lapland longspur	chronic reproductive LOAEL	1.8	ring-necked pheasant	10	0.29	2	2	0.2	Heath et al. 1972
	brant	chronic reproductive LOAEL	1.8	ring-necked pheasant	10	1.05	2	2	0.04	Heath et al. 1972
	glaucous gull	chronic reproductive LOAEL	1.8	ring-necked pheasant	10	1.08	2	2	0.04	Heath et al. 1972
	pectoral sandpiper	chronic reproductive LOAEL	1.8	ring-necked pheasant	10	0.41	2	2	0.1	Heath et al. 1972
	spectacled eider	chronic reproductive LOAEL	1.8	ring-necked pheasant	10	1.06	2	2	0.04	Heath et al. 1972

TABLE 3-18. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF MAMMALS AT THE POINT BARROW INSTALLATION

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg-bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg-bw/day	REFERENCE
DRPH	brown lemming	LD ₅₀	7,380	rat	20	0.60	2	1	308	Beck et al. 1982
	arctic fox	LD ₅₀	7,380	rat	20	2.70	2	1	68	Beck et al. 1982
	caribou	LD ₅₀	7,380	rat	20	7.24	2	1	25	Beck et al. 1982
GRPH	brown lemming	subchronic renal effects NOAEL	500	rat	10	0.60	2	1	42	ATSDR 1993b
	arctic fox	subchronic renal effects NOAEL	500	rat	10	2.70	2	1	9	ATSDR 1993b
	caribou	subchronic renal effects NOAEL	500	rat	10	7.24	2	1	3	ATSDR 1993b
Toluene	brown lemming	reproductive NOAEL	25.98	mouse	1	1.30	2	1	10	Nawrot and Staples 1979 in Opreko et al. 1994
	arctic fox	reproductive NOAEL	25.98	mouse	1	5.82	2	1	2	Nawrot and Staples 1979 in Opreko et al. 1994
	caribou	reproductive NOAEL	25.98	mouse	1	15.59	2	1	1	Nawrot and Staples 1979 in Opreko et al. 1994
Xylenes (Total)	brown lemming	LD ₅₀	4,300	rat	20	0.60	2	1	179	Clayton and Clayton 1981
	arctic fox	LD ₅₀	4,300	rat	20	2.70	2	1	40	Clayton and Clayton 1981
	caribou	LD ₅₀	4,300	rat	20	7.24	2	1	15	Clayton and Clayton 1981
PCBs	brown lemming	reproductive NOAEL	0.135	mouse	1	1.30	2	1	0.05	Opreko et al. 1994
	arctic fox	reproductive NOAEL	0.137	mink	1	1.70	2	1	0.04	Opreko et al. 1994
	caribou	reproductive NOAEL	0.135	mouse	1	15.59	2	1	0.004	Opreko et al. 1994
Iron	brown lemming	acute LD ₅₀	1,000	rat	20	0.60	2	1	42	Shanas and Boyd 1969 in NAS 1980
	arctic fox	acute LD ₅₀	1,000	rat	20	2.70	2	1	9	Shanas and Boyd 1969 in NAS 1980
	caribou	NOAEL; maximum tolerable dietary level	20	sheep	1	1.17	2	1	9	NAS 1980

**TABLE 3-18. TOXICITY REFERENCE VALUES FOR REPRESENTATIVE SPECIES OF MAMMALS AT POINT BARROW INSTALLATION
(CONTINUED)**

CHEMICAL OF CONCERN	REPRESENTATIVE SPECIES	STUDY TYPE	DOSE mg/kg- bw/day	TEST SPECIES	NOAEL UF	SCALING FACTOR	INTERSPECIES UF	PROTECTED SPECIES UF	TRV mg/kg- bw/day	REFERENCE
Lead	brown lemming	reproductive NOAEL	8	rat	1	0.60	2	1	7	Azar et al. 1973 in Opresko et al. 1994
	arctic fox	reproductive NOAEL	8	rat	1	2.70	2	1	1	Azar et al. 1973 in Opresko et al. 1994
	caribou	chronic reproductive NOAEL	0.4	sheep	1	1.17	2	1	0.2	Fick et al. 1976 in NAS 1980
Zinc	brown lemming	chronic reproductive LOAEL	160	rat	1	0.60	2	1	133	Schlicker and Cox 1968 in Opresko et al. 1994
	arctic fox	chronic reproductive LOAEL	160	rat	1	2.70	2	1	30	Schlicker and Cox 1968 in Opresko et al. 1994
	caribou	chronic reproductive LOAEL	160	rat	1	7.24	2	1	11	Schlicker and Cox 1968 in Opresko et al. 1994

subchronic LOEL values. LC_{50} and LD_{50} values are extrapolated to chronic NOAELs by a factor of 20.

- (3) The third step is applicable only to terrestrial receptors. This step extrapolates the estimated NOAEL from the test species to a NOAEL for the species of concern using a body scaling factor. Klaassen et al. (1986) have indicated that dose expressed per unit surface area may be more appropriate than dose per unit body weight. The underlying assumption is that a toxicant acts on a physiologic surface and that the toxic effect increases as the ratio of chemical to surface area increases. The scaling factor (SF) accounts for differences in the mass to surface area ratios between species. In this assessment the scaling factor is calculated using the following equation (Mantel and Schneiderman 1975) (scaling factors are presented in Appendix F):

$$SF = (\text{weight of representative species} / \text{weight of test species})^{1/3}.$$

- (4) A UF of two is used to account for interspecies variation in sensitivity. This value is based on the methodology used in Harding Lawson Associates (1992).
- (5) A UF of two was used to account for additional sensitivity of state and/or federally protected species. This value is based on Harding Lawson Associates (1992). Migratory birds are federally protected and include all the representative avian and protected species selected for this assessment.

The methods of calculating the TRV for the terrestrial and aquatic receptors are as follows:

TERRESTRIAL:

- a) Convert test dose to a NOAEL:
 $\text{DOSE} \div \text{NOAEL UF} = \text{Estimated NOAEL}$
- b) Adjust for body size difference between test species and ROC:
 $\text{Estimated NOAEL} \div \text{SCALING FACTOR} = \text{Scaled, estimated NOAEL}$
- c) Adjust for interspecific differences:
 $\text{Scaled, estimated NOAEL} \div \text{INTERSPECIES UF} = \text{Species-specific, scaled, estimated NOAEL}$
- d) Account for protected species status:
 $\text{Species-specific, scaled, estimated NOAEL} \div \text{PROTECTED SPECIES UF} = \text{TRV}$

AQUATIC:

$$\text{EFFECTIVE CONCENTRATION} \div \text{NOAEL UF} \div \text{INTERSPECIES UF} = \text{TRV}$$

3.4 RISK CHARACTERIZATION FOR ECOLOGICAL RECEPTORS

HQs for the representative species are presented in this section. Potential risks to plants are evaluated based on the contaminant concentrations in the soil/sediment and information from the literature. Potential risks to aquatic organisms, birds, and mammals are estimated by comparing estimated exposures to TRVs (i.e., quotient method). The quotient method divides the estimated exposure concentration by the associated TRV to derive the HQ. If the HQ is less than 1.0, adverse effects are not expected. Conversely, if the HQ is equal to, or greater than, 1.0, a potential for adverse effects exists. The confidence level of the risk estimate is increased as the magnitude of the HQ departs from 1.0. For example, there is greater confidence in a risk estimate where the HQ is 0.1 or 10, than in a HQ such as 0.9 or 1.1. The confidence level is also dependent on the uncertainty associated with the estimated exposure and the TRV for a given chemical-receptor combination.

The characterization of risk focuses on the assessment endpoints. These endpoints are selected and discussed in keeping with the Framework for Ecological Risk Assessment guidance (EPA 1992a). The assessment endpoints for the Point Barrow ERA are changes in:

- the populations of the plant representative species (*Carex* spp., *Salix* spp., *Eriophorum* spp., and *Vaccinium* spp.);
- the populations of aquatic representative species (*Daphnia* spp. and nine-spined stickleback);
- the populations of avian representative and sensitive species (Lapland longspur, brant, glaucous gull, pectoral sandpiper, and spectacled eider); and
- the populations of mammalian representative species (brown lemming, arctic fox, and barren-ground caribou).

The measurement endpoints used to evaluate potential changes in populations of the representative species were based on the endpoints used to derive the TRVs. These endpoints included physiological effects, growth, reproduction, and mortality.

Potential ecological risks to representative species are presented in the following sections: Section 3.4.1 addresses plants; Section 3.4.2 considers aquatic organisms; Section 3.4.3 addresses birds; and Section 3.4.4 discusses mammals. A discussion of potential future risks to ecological receptors is presented in Section 3.4.5. Toxicity information and the HQs that represent potential risk estimates are summarized in the tables for the respective groups of representative species.

3.4.1 Potential Risks to Representative Species of Plants

In determining the risks to plants at the Point Barrow sites, a qualitative comparison was made of soil and surface water contaminant concentrations and plant toxicity information in the literature. Table 3-19 summarizes these comparisons. There is a great deal of uncertainty in this

TABLE 3-19. COMPARISON OF COC CONCENTRATIONS TO TOXICITY INFORMATION FOR PLANTS AT THE POINT BARROW INSTALLATION

CHEMICAL (COC media)	PLANT	EXPOSURE LEVEL	EFFECT ON PLANT	POINT BARROW EXPOSURE	REFERENCE
Iron (COC in water)	Rice	100,000-500,000 µg/L; >500,000 µg/L	Toxic; Highly toxic	4,400 µg/L	USACOE 1991
Lead (COC in soil/sediment)	Weed spp.	500 mg/kg in soil	Reduced pollen germination	120 mg/kg	USACOE 1991
	Weed spp.	46 mg/kg	Normal germination	120 mg/kg	USACOE 1991
Zinc (COC in soil/sediment)	Several spp.	270 mg/kg (avg) in soil	Phytotoxic	160 mg/kg	USACOE 1991
VOCs (COCs as GRPH in water; as DRPH, GRPH, toluene, and xylene in soil/sediment)	Green algae	4,600 µg/L for ethylbenzene 2,290 µg/L for methylene chloride, in water	EC ₅₀	GRPH = 260 µg/L DRPH = 461 µg/L GRPH = 95 mg/kg toluene = 0.7 mg/kg xylenes = 5.68 mg/kg	USACOE 1991
PCBs (Aroclor 1254 in soil/sediment)	Pigweed	40 mg/kg 20 mg/kg	22 percent weight reduction NOAEL	4.8 mg/kg	Strek and Weber 1982 in Will and Suter 1994

phase of the assessment because of the differences in degree of uptake between plant species (Walker et al. 1978); however, the concentrations of contaminants onsite can be compared on the level of orders of magnitude, which can identify broad trends and determine whether a potential risk may exist.

Generally, information is lacking concerning the toxicity of the COCs at Point Barrow and how they relate to the representative species of plants. As a result, when comparisons of TRVs for site-specific species and chemicals are not possible, comparisons of related chemicals with other plant species are made.

As seen in Table 3-19, the concentrations of iron and GRPH in the surface water at Point Barrow are both below the reported toxicity values. The risk posed to plants by VOCs, including DRPH, GRPH, toluene, and xylenes, are not expected to be significant. Toxicity values for vascular plants were not available in the literature, but VOCs are not expected to be present at significant levels in most plants because of their volatility, absorption to soil particles, metabolism, or degradation rates in soil (Kostecki and Calabrese 1989). Lead and zinc concentrations in soil/sediment are also below the reported toxicity values. In addition, the current PCB concentrations at the Point Barrow sites are below the 20 mg/kg NOAEL for Aroclor 1254.

Considering the discussions above, the overall risk to plants from COCs at the Point Barrow sites is not significant.

3.4.2 Potential Risks to Representative Species of Aquatic Organisms

Estimates of exposure for aquatic organisms are based on the average concentrations of each COC in surface water samples (Section 3.1). The HQs for aquatic organisms are presented in Table 3-20. The HQs are calculated by dividing the estimated exposure concentration by the TRV. The following paragraph summarizes the potential risks to aquatic organisms from iron and GRPH, the two COCs identified in surface water.

The HQs for iron in surface water were elevated for *Daphnia* spp. and the nine-spined stickleback. These HQs indicate that a potential risk to aquatic organisms exists from iron concentrations in surface water. These risks are mitigated, however, by the fact that "total" metal concentrations were used to estimate risk and the fact that iron is an essential nutrient. The HQs are based on total concentrations of iron (4,400 µg/L average), which are over 16 times the dissolved concentrations (268 µg/L average). The dissolved concentrations of iron are more likely to drive the toxicity to aquatic organisms, and risks associated with the dissolved concentrations of iron are not significant.

GRPH were evaluated using toxicity data for DRPH because toxicity data for GRPH were not available for aquatic organisms. The chemicals that drive the toxicity of DRPH are often the same as those found in GRPH. The HQs indicate no risk to aquatic organisms. The use of surrogate toxicity data introduces uncertainty to the risk assessment, but the relatively low GRPH concentrations and the low frequency of detection (4 of 13) in surface water samples supports the finding of no significant risk to aquatic organisms from GRPH.

TABLE 3-20. HAZARD QUOTIENTS FOR REPRESENTATIVE SPECIES OF AQUATIC ORGANISMS AT THE POINT BARROW INSTALLATION

SPECIES	ESTIMATED EXPOSURE CONCENTRATION µg/liter	TRV µg/liter	HAZARD QUOTIENT
IRON			
<i>Daphnia</i> spp.	4,400	1,000	4.4
nine-spined stickleback	4,400	1,000	4.4
GRPH			
<i>Daphnia</i> spp.	260	280	0.9
nine-spined stickleback	260	965	0.3

NA = Toxicity data are not available.
NC = Not Calculated.

3.4.3 Potential Risks to Representative Species of Birds

The only HQs greater than one were the pectoral sandpiper's potential exposure to zinc (3) and PCBs (1.1). The HQs for all other representative species of birds and COCs were below one. The avian (and mammalian) HQs are presented in Table 3-21. HQs were not calculated for toluene because no toxicity information was available for avian species; however, a qualitative discussion comparing avian and mammalian toxicity follows.

The pectoral sandpiper forages in surface soil, and its incidental ingestion of soil/sediment is relatively high (about 18 percent). The likelihood of the sandpiper repeatedly foraging at the one sample location where zinc was elevated above background levels (270 mg/kg in soil sample S02 at the Garage [SS02]) is very low. This mitigates the risk associated with the zinc HQ and results in a non-significant risk estimate for the pectoral sandpipers' exposure to zinc. The same rationale may be used to evaluate the risk posed by PCBs. The three locations where Aroclor 1254 was detected (soil samples S02, S03-1, and replicates S04 and S05 at the Garage [SS02]) are under and adjacent to the garage structure on a gravel pad. It is very unlikely that sandpipers would be exposed via repeated foraging at these locations. Combined with the low PCB HQ (1.1), this indicates that the current risk posed by PCBs to sandpipers is not significant.

Quantitative evaluations of GRPH and toluene were not possible because avian toxicity studies for these COCs were not available (although a surrogate evaluation, resulting in a HQ of less than one, was conducted for GRPH using the DRPH toxicity information). A discussion of relative toxicity provides a basis for making qualitative statements concerning their toxicity to avian species. Smith (1987) provides the following ranking of relative toxicities based on median lethal doses (LD_{50} s).

- I. Extremely toxic ($LD_{50} \leq 40$ mg/kg)
- II. Highly toxic (LD_{50} 41-200 mg/kg)
- III. Moderately toxic (LD_{50} 201-1,000 mg/kg)
- IV. Slightly toxic (LD_{50} 1,001-5,000 mg/kg)
- V. Relatively nontoxic ($LD_{50} > 5,000$ mg/kg)

Table 3-22 shows the relative toxicity rankings of GPRH and toluene, based on Smith (1987).

Using the relative toxicities of these COCs, the exposure estimates for avian and mammalian species, and the HQs calculated for mammalian species (see Table 3-21 for exposure estimates and HQs), it is possible to make inferences concerning the potential risk to avian species.

There is limited information available on the relative toxicologic sensitivities of birds compared to mammals. Based upon a review of the species and chemicals tested (Smith 1987; Hudson et al. 1979; Tucker and Leitzke 1979), it appears that avian and mammalian sensitivities (via oral exposure) generally fall within the same range, with birds being slightly more sensitive than mammals. There are, of course, exceptions to this general observation, and for a number of chemicals mammals are more sensitive than birds. For cases where birds are more sensitive, most avian toxicity values fall well within one order of magnitude of the mammalian toxicity values.

TABLE 3-21. HAZARD QUOTIENTS FOR REPRESENTATIVE BIRDS AND MAMMALS AT THE POINT BARROW INSTALLATION

CHEMICAL OF CONCERN	ESTIMATED EXPOSURE mg/kg-bw/day	TRV mg/kg-bw/day	HAZARD QUOTIENT
IRON			
Lapland longspur	4×10^{-1}	55	7×10^{-3}
brant	5×10^{-2}	15	3×10^{-3}
glaucous gull	7×10^{-3}	14	5×10^{-4}
pectoral sandpiper	5×10^{-1}	38	1×10^{-2}
spectacled eider	2×10^{-3}	15	2×10^{-4}
brown lemming	3×10^{-1}	42	7×10^{-3}
arctic fox	3×10^{-1}	9	3×10^{-2}
caribou	3×10^{-3}	9	3×10^{-4}
LEAD			
Lapland longspur	4×10^{-1}	6	7×10^{-2}
brant	1×10^{-1}	6	2×10^{-2}
glaucous gull	1×10^{-2}	6	2×10^{-3}
pectoral sandpiper	3×10^0	6	6×10^{-1}
spectacled eider	7×10^{-4}	6	1×10^{-4}
brown lemming	2×10^0	7	4×10^{-1}
arctic fox	3×10^{-2}	1	3×10^{-2}
caribou	6×10^{-4}	0.2	3×10^{-3}
ZINC			
Lapland longspur	6×10^0	14	4×10^{-1}
brant	2×10^{-1}	4	5×10^{-2}
glaucous gull	2×10^{-2}	4	5×10^{-3}
pectoral sandpiper	3×10^1	10	3×10^0
spectacled eider	3×10^{-2}	4	7×10^{-3}
brown lemming	5×10^1	133	4×10^{-1}
arctic fox	5×10^{-2}	30	2×10^{-3}
caribou	1×10^{-3}	11	1×10^{-4}

TABLE 3-21. HAZARD QUOTIENTS FOR REPRESENTATIVE BIRDS AND MAMMALS AT THE POINT BARROW INSTALLATION (CONTINUED)

CHEMICAL OF CONCERN	ESTIMATED EXPOSURE mg/kg-bw/day	TRV mg/kg-bw/day	HAZARD QUOTIENT
DRPH			
Lapland longspur	2×10^0	520	5×10^{-3}
brant	6×10^{-1}	140	5×10^{-3}
glaucous gull	9×10^{-2}	140	6×10^{-4}
pectoral sandpiper	2×10^1	360	5×10^{-2}
spectacled eider	4×10^{-3}	140	3×10^{-5}
brown lemming	1×10^1	310	4×10^{-2}
arctic fox	1×10^0	68	2×10^{-2}
caribou	4×10^{-3}	25	2×10^{-4}
GRPH			
Lapland longspur	2×10^{-1}	NA	NC
brant	9×10^{-2}	NA	NC
glaucous gull	1×10^{-2}	NA	NC
pectoral sandpiper	2×10^0	NA	NC
spectacled eider	4×10^{-4}	NA	NC
brown lemming	1×10^0	42	3×10^{-2}
arctic fox	2×10^{-2}	9	2×10^{-3}
caribou	6×10^{-4}	3	2×10^{-4}
TOLUENE			
Lapland longspur	3×10^{-3}	NA	NC
brant	1×10^{-4}	NA	NC
glaucous gull	2×10^{-5}	NA	NC
pectoral sandpiper	2×10^{-2}	NA	NC
spectacled eider	2×10^{-5}	NA	NC
brown lemming	3×10^{-2}	10	3×10^{-3}
arctic fox	2×10^{-8}	2	1×10^{-8}
caribou	9×10^{-7}	1	9×10^{-7}

TABLE 3-21. HAZARD QUOTIENTS FOR REPRESENTATIVE BIRDS AND MAMMALS AT THE POINT BARROW INSTALLATION (CONTINUED)

CHEMICAL OF CONCERN	ESTIMATED EXPOSURE mg/kg-bw/day	TRV mg/kg-bw/day	HAZARD QUOTIENT
XYLENES (total)			
Lapland longspur	3×10^{-2}	26	2×10^{-3}
brant	1×10^{-3}	7	1×10^{-4}
glaucous gull	2×10^{-4}	7	4×10^{-5}
pectoral sandpiper	2×10^{-1}	18	5×10^{-2}
spectacled eider	2×10^{-4}	6	4×10^{-3}
brown lemming	3×10^{-1}	180	7×10^{-3}
arctic fox	3×10^{-6}	40	2×10^{-6}
caribou	9×10^{-6}	15	3×10^{-6}
PCBs (Aroclor 1254)			
Lapland longspur	1×10^{-2}	0.2	6×10^{-2}
brant	4×10^{-3}	0.04	1×10^{-1}
glaucous gull	6×10^{-4}	0.04	1×10^{-2}
pectoral sandpiper	1×10^{-1}	0.1	1×10^0
spectacled eider	1×10^{-4}	0.04	3×10^{-3}
brown lemming	6×10^{-2}	0.05	1×10^0
arctic fox	5×10^{-5}	0.04	1×10^{-3}
caribou	2×10^{-5}	0.004	6×10^{-3}

NA Not available.
NC Not calculated.

TABLE 3-22. RELATIVE TOXICITY RANKINGS FOR COMPARISON OF MAMMALIAN AND AVIAN TOXICITY

COC	STUDY TYPE*	DOSE (mg/kg/day)	RELATIVE TOXICITY
GRPH	oral rat LD ₅₀	14,063 ^a	relatively non-toxic
toluene	oral rat LD ₅₀	5,000 ^b	slightly toxic

^a ATSDR 1993b.

^b Sax and Lewis 1989.

As noted, avian toxicity values are not available for some COCs in this ERA. However, based on the information presented above, these chemicals are not expected to be significantly more toxic to birds than to mammals. Birds are not expected to be at risk given that there are no HQs for GRPH or toluene above one for mammals, and the estimated exposures for birds are sufficiently lower than those for mammals to offset the possibility that some birds may be more sensitive than mammals to these selected COCs. This qualitative discussion and the inter-taxa toxicity estimates introduce additional elements of uncertainty to the risk assessment. See Section 3.5, Uncertainty Analysis, for more discussion of this topic.

Based on the above discussions and the HQs presented in Table 3-21, the risk estimates for the avian representative species at the Point Barrow installation are not significant.

3.4.4 Potential Risks to Representative Species of Mammals

HQs for the brown lemming, arctic fox, and the barren-ground caribou are below 1.0 for all COCs with the exception of the brown lemmings' PCB HQ of 1.1. The estimated exposures, TRVs, and HQs are presented in Table 3-21. Although this could indicate potential risk to the brown lemming, this risk is mitigated because the three locations at which PCBs are detected (soil samples S02, S03-1, and replicates S04 and S05 at the Garage [SS02]) are under and adjacent to the garage structure on a gravel pad. It is unlikely that the population of lemmings at the Point Barrow installation would be exposed to the soil at these locations because no vegetation is present and the gravel pad is an unlikely place for the lemmings to burrow. The distribution of the brown lemming population, the probability for exposure to PCBs at the detected locations, and the low magnitude of the PCB HQ (based on exposure at the detected locations), indicate that the risk to the lemming posed by PCBs is not significant.

Based on the calculated HQs and the discussion above, the risk estimates for mammals at the Point Barrow installation are not significant. Refer to Section 3.5, Uncertainty Analysis, for a more detailed discussion of the uncertainties associated with this risk estimate.

3.4.5 Potential Future Risks

Estimates of future risk at the Point Barrow installation are based on the assumption that the gravel pads will remain in place and that the sites will remain suitable habitat for the

representative species. Future risks related to DRPH, GRPH, toluene, xylene, iron, lead, and zinc at the Diesel Fuel Spill (SS01), Garage (SS02), and Air Terminal Area (SS03) are expected to be as low as, or lower than, current risks (i.e., not significant) because the exposure pathways are not likely to change, and the concentrations of COCs are likely to diminish over time.

Future risk estimates at the Garage for PCB contamination may be greater than the current estimates because of the high potential for PCBs to bioaccumulate. PCBs have very high chemical, thermal, and biological stability in addition to low vapor pressure (Manahan 1994). Conversion of highly substituted PCBs to molecules with one or two chlorines is done relatively slowly by anaerobic bacteria (Manahan 1994). Therefore, natural biodegradation may not be an effective process for significantly reducing the PCBs to concentrations that are protective of the environment.

Risk estimates related to potential exposure to PCBs under current conditions at the Garage are not significant. There is potential for this estimate to increase over time as potential pathways for PCB exposure may be completed. It is not possible to quantify the future risk estimate for PCBs, and the qualitative estimate can only state that the future risk is potentially greater than the current risk estimate.

3.5 ECOLOGICAL RISK ASSESSMENT UNCERTAINTY ANALYSIS

As with any risk assessment, there is great uncertainty associated with the estimates of ecological risk for the sites at the Point Barrow installation. The risk estimates are based on a number of assumptions regarding exposure and toxicity. In general, the primary sources of uncertainty are the following:

- Environmental Sampling and Analysis;
- Selection of COCs;
- Selection of Representative Species;
- Exposure Parameter Estimation; and
- Toxicological Data.

A complete understanding of the uncertainties associated with risk estimates is critical to placing the predicted risks in proper perspective. The most significant sources of uncertainty associated with the estimates of risk for the Point Barrow installation sites are summarized in the following sections.

3.5.1 Environmental Sampling and Analysis

The principal source of uncertainty in the analytical data (for the ERA) stems from the sampling approach and the subsequent calculation of exposure concentrations. Sampling at the Point Barrow installation was conducted in a systematic manner, designed to characterize localized contaminated areas or "hot spots". In order to partially compensate for this non-random sampling methodology in the calculation of exposure concentrations, the exposure assessment used the average concentration of COCs across the site.

The methods of calculating the average concentrations were the same for organic and inorganic data. In calculating the average concentration of chemicals at the site, non-detected chemicals were entered at one-half of the quantitation limit, as per EPA guidance (EPA 1989a). The use of total metal concentrations in surface water to estimate risk is a conservative approach because dissolved metal concentrations are generally significantly less than total metal concentrations. Therefore, the average concentrations of total metals used to estimate exposure in surface water may overestimate potential risk.

The number of metal analyses is a factor that also contributes to uncertainty. Of the 14 surface water samples, three were analyzed for metals, and the soil/sediment samples were analyzed for metals in two of 33 instances. The selection of the inorganic COCs was based on these analyses and the resultant choices may under- or overestimate the true nature and extent of metals contamination at the Point Barrow installation. It is difficult to assess the impact that this uncertainty has on the overall risk estimates, although the available data indicate that metals contamination is not likely to present risks at Point Barrow.

The sample quantitation limits for several metals were higher than the action levels used to screen the chemicals. Therefore, non-detected concentrations of beryllium, cadmium, copper, chromium, lead, selenium, silver, and thallium may be present in quantities sufficient to elicit adverse effects in aquatic organisms. This probably contributes a low level of uncertainty to the overall risk estimate because surface water pathways at the Point Barrow installation are not likely to be significant routes of exposure to representative species other than *Daphnia* spp.

There is uncertainty inherent in using measurements of petroleum hydrocarbon analyses (DRPH, GRPH, and RRPH) for risk assessments. The analytical techniques are not specific to petroleum (i.e., they detect other organics, including naturally-occurring ones) (Von Burg 1993). Moreover, the toxicity of these groups of petroleum hydrocarbons is determined by the toxicity of their individual constituents. When petroleum compounds are released to the environment, they tend to weather or transform readily. For example, the lighter fractions (such as BTEX) will volatilize to the atmosphere more readily than the heavier fractions (such as decane, pyrene, or benzo(a)pyrene). The lighter fractions are thought to be the more toxic (Wong et al. 1981; O'Brien 1978; Kauss and Hutchinson 1975; and Soto et al. 1975). Therefore, the toxicity of DRPH, GRPH, and RRPH is expected to change over time depending upon the attenuation mechanisms occurring in the environment. As a result, the toxicity of the petroleum hydrocarbons detected at the Point Barrow sites is unknown. Use of toxicity values reported in the literature probably contributes to an overestimation of the risk because it is likely that the most toxic components of the mixtures detected have volatilized to the atmosphere over time.

3.5.2 Selection of Chemicals for Evaluation

The selection of COCs in the ERA was based upon a comparison to background concentrations and action levels, and an evaluation of the frequency of detection. For certain chemicals, no action levels were available, and action levels for related compounds were used. This introduces some uncertainty into the risk assessment as actual toxicity may be different from the toxicity of the surrogate chemical. Overall, however, the process provided a conservative screen of COCs, and it is unlikely that any chemicals presenting an ecological risk were omitted.

3.5.3 Selection of Representative Species

The selection of representative species in the ERA introduces some uncertainty into the risk estimates. No site-specific biological surveys were conducted at the Point Barrow installation, with the exception of a survey for spectacled and Steller's eiders (Alaska Biological Research 1994). As a result, it is not known whether or how often the representative species are actually found at the site; however, the uncertainty introduced into the risk estimate by this route is likely to be low. The purpose of ERAs is not to survey the biota at a site, but to estimate the risks to species that may inhabit the area. Surrogate species are commonly used, even if the representative species do not reside specifically at the Point Barrow installation. As a result, the risk estimates in this report provide a sound measure of the potential risks to the species that do inhabit the area.

3.5.4 Exposure Assessment

Exposures were estimated using literature-based life history information for the selected representative species. There is moderate uncertainty associated with the exposure information. Food and water ingestion rates were not available for some animals and were estimated from regression equations. Incidental ingestion of soils and sediments may occur while animals are foraging, and it is uncertain how much is actually ingested. In addition, there is uncertainty associated with the habitat associated at the site. Samples were collected around buildings and other structures that are likely to provide habitat of limited quality. As a result, this tends to overestimate exposure. Further, there are significant uncertainties associated with the estimates of how extensively a receptor will use the site, which were based on home range information. As noted in the discussion of Estimation of Percent Ingested Onsite, Section 3.2.7.2, the conversion of population density values as substitutes for home ranges adds uncertainty to the risk assessment. The conversion was necessary because home range data are lacking for some of the representative species.

There is some uncertainty associated with the diet compositions estimated from the literature. A good example of this type of uncertainty is the unpredictable fluctuation in the populations of the brown lemmings and their predators (i.e., arctic fox, glaucous gull). As the numbers of prey increase, predator populations may experience numerical and density increases well beyond the values reported in the literature. When prey populations decrease, predation pressure can shift to diet items not considered "normal", that do not represent dietary intakes reported in the literature. Wildlife, and their interactions with the environment around them, are dynamic. Stochastic events, natural or anthropogenic, may cause behavior and/or habits to differ markedly from the "expected or norm". Deviations from typical behavior cause uncertainty when evaluating wildlife and ecosystems.

There is uncertainty associated with exposure estimates for plants. Plant uptake of COCs was derived from a regression equation using the K_{ow} of the COC (Table 3-5). This calculation estimates the concentration of chemicals in the vegetative portion of plants. Actual concentrations of the COC in plant tissue will vary depending upon actual chemical uptake, species of plant, and other site-specific factors (such as soil organic carbon). It is important to note that screening level tissue concentrations in plants were not available for comparison with

these estimated concentrations. The overall effect of this source of uncertainty in the risk assessment is low, as is the ecological risk to plants.

The only component in the diet of representative species evaluated quantitatively was the ingestion of plants. Ingestion of animal prey (e.g., the diet of the arctic fox and the insectivorous portion of some avian diets) was not quantified. This may slightly underestimate risk for species that rely on animal items in their diet.

3.5.5 Toxicological Data

One of the largest sources of uncertainty in risk assessment is from the toxicological data. Often there are not relevant studies for the specific representative species or endpoints. As a result, extrapolations are made, which introduce uncertainty into the risk estimate. These extrapolations incorporate UFs into the calculation of TRVs. The purpose of the UFs is to incorporate some margin of error into the risk estimate, in order to arrive at a "safe" level of exposure to which onsite exposure concentrations may be compared. These techniques introduce into the risk assessment a tendency to overestimate rather than underestimate the risk, as conservative estimates were made in estimating toxicity values.

For some chemicals, no toxicity information was available (e.g., avian toxicity values for BTEX and several VOCs for birds). As a result, these compounds were not evaluated quantitatively in the risk assessment, and the risk may be somewhat underestimated. Based on the low concentrations and low frequency of detection of these compounds (as discussed in Section 3.1), the uncertainty associated with this factor is low.

Toxicity values for plants, water, soils, and sediments are based on literature values. Toxicity in soils and sediments is affected by the bioavailability of a given chemical. Toxicity of metals in water is based, in part, upon the speciation of the element. As a result, site-specific bioavailability or toxicity may differ from that in the studies used to estimate potential toxic effects. Therefore, actual toxicities of chemicals at the Point Barrow sites may be different from the values reported in the literature. In addition, the sensitivity of receptors on site may be different from the sensitivity of the species reported in the literature.

There is a great deal of uncertainty in assessing the toxicity of a mixture of chemicals. In this ERA, the effects of exposure from each contaminant have been considered separately. These substances occur together at the site; however, and organisms may be exposed to mixtures of the chemicals. Prediction of how these mixtures of toxicants will interact must be based on an understanding of the mechanisms of such interactions. Interactions of the individual components of chemical mixtures may occur during absorption, distribution, metabolism, excretion, or activity at the receptor site. Individual compounds may interact chemically, yielding a new toxic component or causing a change in the biological availability of an existing component, or may interact by causing different effects at different receptor sites. Suitable data are not currently available to characterize the effects of chemical mixtures rigorously, so chemicals present at the site were evaluated independently. This approach of assessing risk associated with mixtures of chemicals does not account for any additive, synergistic, or antagonistic interactions among the

chemicals considered. However, as discussed in Section 3.6, the risk assessment yielded a low potential for ecological risks, and it is unlikely that additive effects of chemicals are a concern.

3.6 SUMMARY OF ECOLOGICAL RISK

The potential risks to ecological receptors are summarized in this section based on the information presented in Sections 3.1 through 3.4. The reader is referred to these sections for more details on the assessment. Conclusions regarding potential risks must be viewed in the context of the uncertainties associated with the assessment (Section 3.5) and the available risk information. The available risk information includes chemical data, exposure estimates, and literature-based toxicity information.

Table 3-23 summarizes the ecological risks at the Point Barrow installation. The table shows the COCs associated with potential risks on a site-by-site basis for current and future conditions.

3.6.1 Potential Risks to Representative Plants

A qualitative comparison was conducted of onsite soil/sediment and surface water concentrations with plant toxicity information. The risk to plants is characterized using comparative information from the literature and BCF (B_v). Based on the qualitative comparison, the risks to plants are not significant.

3.6.2 Potential Risks to Representative Aquatic Species

Potential risks to aquatic species were evaluated by comparing toxicity information from the literature with the average exposure concentrations of potential contaminants in surface water. Although the HQs for aquatic organisms indicate that potential for risks from iron may exist, a qualitative discussion in Section 3.4.2, Risk Characterization, points out factors that mitigate this potential for risk. Therefore, considering site and COC-specific factors, the overall risk to aquatic organisms at the Point Barrow installation is not considered significant.

TABLE 3-23. SUMMARY OF ECOLOGICAL RISK ESTIMATES AT THE POINT BARROW SITES

SITE	COC CONTRIBUTING TO RISK	CURRENT RISK POTENTIAL	FUTURE RISK POTENTIAL
Diesel Fuel Spill (SS01)	None	not significant	not significant
Garage (SS02)	PCBs (Aroclor 1254)	not significant	may increase to a significant level because of bioaccumulation
Air Terminal Area (SS03)	None	not significant	not significant

3.6.3 Potential Risks to Representative Species of Birds and Mammals

The risks to representative species of birds and mammals were evaluated using the quotient method. This method compares the estimated exposures with TRVs, resulting in a calculated HQ. In some cases, HQs were not calculated for avian species because of the lack of COC-specific toxicity information; they were evaluated using a qualitative comparison with the mammalian toxicities in Section 3.4.3, Risk Characterization. The resulting risk estimates for all of the avian and mammalian representative species were not significant. In addition, the risks resulting from potential future exposure to COCs at the Point Barrow installation (with the exception of Aroclor 1254 contamination at the Garage site (SS02) are estimated to be as low as, or lower than, the current estimates (i.e., not significant).

The objective of this ERA is to evaluate the potential risk to the representative plant, aquatic, and terrestrial species at the Point Barrow DEW Line installation. The assessment indicates that, overall, the potential ecological risks currently presented by the COCs at the Point Barrow sites are not significant. There is potential for ecological risk in the future as a result of PCB contamination at the Garage site (SS02).

THIS PAGE INTENTIONALLY LEFT BLANK

4.0 REFERENCES

- Agency for Toxic Substances and Disease Registry (ATSDR). 1990a. Toxicological Profile for Styrene. Draft Report. U.S. Department of Health and Human Services.
- Agency for Toxic Substances and Disease Registry (ATSDR). 1990b. Toxicological Profile for Cobalt. Draft Report. U.S. Department of Health and Human Services.
- Agency for Toxic Substances and Disease Registry (ATSDR). 1993a. Toxicological Profile for Fuel Oils. Draft Report. U.S. Department of Health and Human Services.
- Agency for Toxic Substances and Disease Registry (ATSDR). 1993b. Toxicological Profile for Automotive Gasoline. Draft Report. U.S. Department of Health and Human Services.
- Alaska Biological Research. 1994. Spectacled and Steller's Eiders Surveys at 11 CEOS Remote Sites in Alaska, 1994. Fairbanks, Alaska. 30 September 1994.
- Alaska Department of Environmental Conservation. 1989. Water Quality Standards 18 AAC 70. Prepared for the Triennial Review required by the Federal Clean Water Act (December 1989).
- Alaska Department of Environmental Conservation. 1991. Interim Guidance for Non-UST Contaminated Soil Cleanup Levels. Guidance Number 001, Revision 1. Alaska Department of Environmental Conservation, Juneau, Alaska. July 17, 1991.
- Albers, P.H. 1977. Effects of External Applications of Fuel Oil on Hatchability of Mallard Eggs. Pages 158-163 in D.A. Wolfe (Ed). Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms. Pergamon Press, New York.
- Ambrose, S. 1994. Personal communication with S. Ambrose, a threatened and endangered species specialist with the U.S. Fish and Wildlife Service. Don Kellett, ICF Kaiser Engineers, Lakewood, Colorado. 31 March 1994.
- American Petroleum Institute (API). 1994. Results of Toxicological Studies Conducted for the American Petroleum Institute. API Publication No. 45591. January 1994.
- Aquatic Information Retrieval (AQUIRE). 1990. Computerized Database. Chemical Information System, Inc. Baltimore, Maryland.
- Aquatic Information Retrieval (AQUIRE). 1994. Computerized Database. Chemical Information System, Inc. Baltimore, Maryland.
- Armstrong Laboratory. 1994. Evaluation of the Total Petroleum Hydrocarbon Standard at Jet Fuel Contaminated Air Force Sites. Prepared by EA Engineering, Science and Technology Inc. for Armstrong Laboratory, Brook AFB, Texas. January.

- Baes, C.F., III, R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture. Oak Ridge National Laboratory. Prepared for the U.S. Department of Energy, Contract No. DE-AC05-84OR21400.
- Beck, L.S., D.I. Hepler, and K.L. Hansen. 1982. The Acute Toxicology of Selected Petroleum Hydrocarbons. Pages 1-12 in H.N. MacFarland, C.E. Holdsworth, J.A. MacGregor, R.W. Call, and M.L. Kaen (Eds). Proceedings of the Symposium - The Toxicology of Petroleum Hydrocarbons. American Petroleum Institute. Washington, D.C.
- Belopol'skii, L.O. 1961. Ecology of Sea Colony Birds of the Barents Sea. Translated from the Russian Original. Israel Program for Scientific Translations. Jerusalem, Israel.
- Bergman, R.D., R.L. Howard, K.F. Abraham, and M.W. Weller. 1977. Water Birds and Their Wetland Resources in Relation to Oil Development at Storkersen Point, Alaska. Resource Publication 129. U.S. Fish and Wildlife Service. Washington D.C.
- Beyer, N., E. Conner, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J. Wildl. Manage. 58(2):375-382.
- Bott, T.L. and K. Rogenmuser. 1978. Effects of No. 2 Fuel Oil, Nigerian Crude Oil, and Used Crankcase Oil on Attached Algal Communities: Acute and Chronic Toxicity of Water-Soluble Constituents. Applied and Environmental Microbiology. November 1978:673-682.
- Brewster, K. 1994. Personal communication with North Slope Borough oral historian. April 13, 1994.
- Burt, W.H. and R.P. Grossenheider (Eds). 1976. A Field Guide to the Mammals. Third Edition. Houghton-Mifflin Co., Boston, Massachusetts.
- Calder, W.A. and E.J. Braun. 1983. Scaling of Osmotic Regulation in Mammals and Birds. Am J. Physiol. 244:R601-R606.
- Cameron, R.D., D.J. Reed, J.R. Dau, and W.T. Smith. 1992. Redistribution of Calving Caribou in Response to Oil Field Development on the Arctic Slope of Alaska. Arctic 45(4):338-342.
- CH2M Hill. 1981. Installation Restoration Program Search, Alaska DEW Line Stations. Prepared for the U.S. Air Force.
- Chance, N. 1990. The Inupiat and Arctic Alaska: An Ethnography of Development. Holt, Rinehart, and Winston, New York. pp. 241.
- Chappell, M.A. 1980. Thermal Energetics and Thermoregulatory Costs of Small Arctic Mammals. J. Mamm. 61(2):278-291.

- Chesemore, D.L. 1967. Ecology of the Arctic Fox in Northern and Western Alaska. M.S. Thesis, University of Alaska, Fairbanks.
- Clayton, G.D. and F.E. Clayton (Eds). 1981-1982. Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. Third Edition. John Wiley Sons, New York, New York. pp. 3292.
- Cuccarese, S.V., M.F. Arend, R.J. Hensel, and P.O. McMillan. 1984. Biological and Socioeconomic Systems of the BAR-M, POW-1, LIZ-3A and SI-1 North Warning System Sites, Alaska. AEIDC. University of Alaska, Anchorage.
- Custance, S.R., P.A. McCaw, A.C. Kopf, and M.J. Sullivan. 1992. Environmental Fate of the Chemical Mixtures: Crude Oil, JP-5, Mineral Spirits and Diesel Fuel. Journal of Soil Contamination 1(4):379-386.
- Custer, T.W. and F.A. Pitelka. 1978. Seasonal Trends in Summer Diet of the Lapland Longspur Near Barrow, Alaska. Condor 80:295-301.
- Delos, C. 1995. Personal communication with Charles Delos, United States Environmental Protection Agency. Karen Prochnow, ICF Kaiser Engineers. 25 April 1995.
- Derksen, D.V., T.C. Rothe, and W.D. Eldridge. 1981. Use of Wetland Habitats by Birds in the National Petroleum Reserve - Alaska. U.S. Fish and Wildlife Service, Resource Publication 141. Washington, D.C.
- Dunning, J.B. 1984. Body Weights of 686 Species of North American Birds. Western Bird Banding Association. Monograph No. 1. Cave Creek, Arizona.
- Eberhardt, L.E., W.C. Hanson, J.L. Bengtson, R.A. Garrott, and E.E. Hanson. 1982. Arctic Fox Home Range Characteristics in an Oil-Development Area. J. Wildl. Manage. 46(1):183-190.
- Eisler, R. 1986. Polychlorinated Biphenyl Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service. Biological Report 85(1.7). Laurel, Maryland.
- Eisler, R. 1988. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service. Contaminant Hazard Reviews Report No. 14. Biological Report 85 (1.14).
- Eisler, R. 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service. Biological Report 10. Laurel, Maryland.
- Farrand, J., Jr. (Ed). 1983. The Audubon Society Master Guide to Birding, Volume 2. Alfred A. Knopf, New York, New York. 398 pp.

- Geiger, J.G. and A.L. Buikema, Jr. 1981. Oxygen Consumption and Filtering Rate of *Daphnia pulex* After Exposure to Water-Soluble Fractions of Naphthalene, Phenanthrene, No. 2 Fuel Oil and Coal-tar Creosote. *Bulletin of Environmental Contamination and Toxicology* 27:783-789.
- Hansen, C. 1995. Personal communication with Carl Hansen of Shiltec-Alaska, consultants to North Slope Borough Capital Improvements Project Department. June 28, 1995.
- Harcharek, R.C. 1994. North Slope Borough 1993/94 Economic Profile and Census Report, Volume VII. North Slope Borough, Department of Planning and Community Services, Barrow, Alaska.
- Harding Lawson Associates. 1992. Offpost Operable Unit Endangerment Assessment/ Feasibility Study. Final Report. Technical Support for Rocky Mountain Arsenal. 24 November 1992. Prepared for Program Manager for Rocky Mountain Arsenal.
- Hart Crowser. 1987. Environmental Assessment for North Warning System. Alaska.
- Hartung, R. 1964. "Some Effects of Oils on Waterfowl." PhD Thesis. University of Michigan, Ann Arbor. Pages 426-436 in R.C. Szaro, M.P. Dieter G.H. Heinz, and J.F. Ferrell. 1978. Effects of Chronic Ingestion of South Louisiana Crude Oil on Mallard Ducklings. *Environmental Research* 17:426-436.
- Haseltine, S.D. and R.M. Prouty. 1980. Aroclor 1242 and Reproductive Successes of Adult Mallards (*Anas platyrhynchos*). *Environ. Res.* 23:29-34.
- Hazardous Substance Data Bank (HSDB). 1994. National Institute of Health. Bethesda, Maryland.
- Heath, J.S., K. Koblis, and S.L. Sager. 1993. Review of Chemical, Physical, and Toxicologic Properties of Components of Total Petroleum Hydrocarbons. *J. of Soil Contamination*. 2(i): 1-25.
- Heath, R.G., J.W. Spann, E.F. Hill, and J.F. Kreitzer. 1972. Comparative Dietary Toxicities of Pesticides to Birds. U.S. Fish and Wildlife Service. Special Scientific Report - Wildlife 152. 57 p.
- Hedtke, S. and F.A. Puglisi. 1982. Short-Term Toxicity of Five Oils to Four Freshwater Species. *Archives of Environmental Contamination and Toxicology* 11:425-430.
- Hensel, R., M.F. Arend, J. Thiele, P.O. McMilland, and S.V. Cuccarese. 1984. Living Resources of the Point Barrow, Oliktok Point and Boulder Creek Areas, Alaska: A Literature Survey. AEIDC. University of Alaska, Anchorage.

- Hill, E.F. and M.B. Camardese. 1986. Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to *Coturnix*. U.S. Fish and Wildlife Service. Technical Report 2. Washington, D.C. 147 p.
- Hoffman, D.J., J.C. Franson, O.H. Pattee, C.M. Bunck, and A. Anderson. 1985. Survival, Growth and Accumulation of Ingested Lead in Nestling American Kestrels (*Falco sparverius*). Arch. Environ. Contam. Toxicol. 14:89-94.
- Hudson, R.H., M.A. Haegle, and R.K. Tucker. 1979. Acute Oral and Percutaneous Toxicity of Pesticides to Mallards: Correlations with Mammalian Toxicity Data. Toxicology and Applied Pharmacology 47:451-460.
- Hull, R.N. and G.W. Suter II. 1994. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment Associated Biota: 1994 Revision. ORNL Environmental Restoration Program. ES/ER/TM-95/R1.
- IRIS. 1995. Integrated Risk Information System. Environmental Criterion Assessment Office, U.S. Environmental Protection Agency, Cincinnati, Ohio.
- Johnson, L. and B. Burns (Eds). 1984. Biology of the Arctic Char: Proceedings of the International Symposium on Arctic Char. University of Manitoba Press, Winnipeg, Man., Canada. 584 pp.
- Kauss, P.B. and T.C. Hutchinson. 1975. The Effects of Water-Soluble Petroleum Components on the Growth of *Chlorella vulgaris*, Beijerinck. Environmental Pollution (9):157-174.
- Kistchinski, A.A. and V.E. Flint. 1974. On the Biology of the Spectacled Eider. Wildfowl 25:5-15.
- Klaassen, C.D., M.O. Amdur, and J. Doull. 1986. Casarett and Doull's Toxicology, the Basic Science of Poisons. Third Edition. MacMillan Publishing Company. New York. 974 pp.
- Klein, S.A. and D. Jenkins. 1983. The Toxicity of Jet Fuels to Fish - II. Water Research 17 (10):1213-1220.
- Kostecki, P.T. and E.J. Calabrese. 1989. Petroleum Contaminated Soils. Volume 1. Lewis Publishers, Chelsea, Michigan. 357 pp.
- Kraus, M.L. 1989. Bioaccumulation of Heavy Metals in Pre-Fledgling Tree Swallows, *Tachycineta Bicolor*. Bull. Environ. Contam. Toxicol. 43:407-414.
- Lindsay, W.L. 1979. Chemical Equilibria in Soils. John Wiley and Sons, New York, New York. 449 pp.

- Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt (Eds). 1982. Research and Development Methods for Estimating Physio-Chemical Properties of Organic Compounds of Environmental Concern. Report No. C-82426 by Arthur D. Little, Inc., under contract DAMD-17-78-C-0873, U.S. Army Medical R&D Command. Fort Detrick, Maryland.
- Manahan, S.E. 1994. Environmental Chemistry. Sixth Edition. Lewis Publishers, Inc. Chelsea, Minnesota.
- Mantel, N. and M.A. Schneiderman. 1975. Estimating Safe Levels: A Hazardous Undertaking. *Cancer Res.* 35:1379-1386.
- Martin, A.C., H.S. Zim, and A.L. Nelson. 1961. American Wildlife and Plants: A Guide to Wildlife Food Habits. Dover Publications, New York. 500 pp.
- Massachusetts Department of Environmental Protection (MDEP). 1993. Petroleum Policy: Development of Health-Based Alternative to the TPH Parameter. Prepared by ABB Environmental Services, Inc., Wakefield, Massachusetts. Project No. 06979-00. August.
- Mautino, M. and J.U. Bell. 1987. Hematological Evaluation of Lead Intoxication in Mallards. *Bull. Environ. Contam. Toxicol.* 38:29-34.
- MITRE. 1990. General Guidance for Ecological Risk Assessment at Air Force Installations. J.M. DeSossa, Ph.D. and F.T. Price, Ph.D., December 1990.
- Moles, A., S.D. Rice, and S. Korn. 1979. Sensitivity of Alaskan Freshwater and Anadromous Fishes to Prudhoe Bay Crude Oil and Benzene. *Transactions of the American Fisheries Society* 108:408-414.
- Nagy, K.A. 1987. Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds. *Ecol. Mono.* 57:111-128.
- National Academy of Sciences. 1980. Mineral Tolerance of Domestic Animals. Subcommittee on Mineral Toxicity in Animals. National Research Council. Washington, D.C.
- National Oceanic and Atmospheric Administration (NOAA). August 1991. The Potential for Biological Effects of Sediment Sorbed Contaminants Tested in the National Status and Trends Program. Technical Memorandum NOS OMA 52. NOAA, Seattle, Washington.
- National Petroleum Reserve in Alaska Task Force (NPRA). 1978. Land Use Study, Volume 2. Values and Resource Analysis. U.S. Department of the Interior. Anchorage, Alaska.
- Nowak, R.M. (Ed). 1991. Walker's Mammals of the World. Fifth Edition. Johns Hopkins University Press, Baltimore, Maryland.
- O'Brien, J.W. 1978. Toxicity of Prudhoe Bay Crude Oil to Alaskan Arctic Zooplankton. *Arctic* 31(3):219-228.

- Opresko, D.M., B.E. Sample, and G.W. Suter II. 1994. Toxicological Benchmarks for Wildlife: 1994 Revision. ORNL Environmental Restoration Program. ES/ER/TM-86/R1.
- Palmer, R.S. (Ed). 1976. Handbook of North American Birds, Volume 2, pp. 244-273. Yale University Press, New Haven, Connecticut. 521 pp.
- Platanow, N.S. and L.H. Karstad. 1973. Dietary Effects of Polychlorinated Biphenyls on Mink. Can. J. Comp. Med. 37:391-400.
- Pitelka, F.A. 1959. Numbers, Breeding Schedule, and Territoriality in Pectoral Sandpipers of Northern Alaska. Condor 62(4)233-264.
- Raven, P.H., R.H. Evert, and F.E. Eichorn. 1986. Biology of Plants. Worth Publishers, Inc. New York, New York. 775 pp.
- Ringer, R.K. 1983. Toxicology of PCBs in Minks and Ferrets In: F.M. D'Itri and M.A. Kamrin (Eds.). PCBs: Human and Environmental Hazards. Ann Arbor Science Book. Butterworth Publishers, Boston, Massachusetts.
- Sangster Research Laboratories and Technical Database Services, Incorporated. 1994. Log Kow Database. Accessed August 21, 1995.
- Sax, I. and R.J. Lewis, Sr. 1989. Dangerous Properties of Industrial Materials. Seventh Edition. Van Nostrand, Reinhold, New York.
- Scott, S.L. 1983. Field Guide to the Birds. National Geographic Society. Washington, D.C. 464 pp.
- Shacklette, H.T. and J.G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. U.S. Geological Survey Professional Paper 1270. USGS, Alexandria, Virginia. 105 pp.
- Shannon and Wilson, Inc. 1991. Final Report Supplemental Remedial Investigation for the Comprehensive Long-Term Environmental Action (Navy Clean Program) Northwest Area. April.
- Skogland, T. 1980. Comparative Summer Feeding Strategies of Arctic and Alpine Rangifer. Journal of Animal Ecology. 49:81-98.
- Smith, G.J. 1987. Pesticide Use and Toxicology in Relation to Wildlife: Organophosphorus and Carbamate Compounds. U.S. Fish and Wildlife Service, Resource Publication 170. Washington, D.C.
- Snyder-Conn, E. 1994. Personal communication with E. Snyder-Conn, Wildlife Biologist with the U.S. Fish and Wildlife Service, Fairbanks, Alaska. Don Kellett, ICF Kaiser Engineers. 31 March 1994.

- Soto, C., J. Hellebust, and T.C. Hutchinson. 1975. Effect of Napthalene and Aqueous Crude Oil Extracts on the Green Flagellate *Chlamydomonas Angulosa*. Canadian J. of Botany 53(2):118-126.
- Spacie, A. and J.L. Hamelink. 1985. Bioaccumulation, Chapter 17, pp. 495-525 in Fundamentals of Aquatic Toxicology. G.M. Rand and S.R. Petrocelli (Eds). Hemisphere Publishing Corporation, New York.
- Suter, G.W and J.B. Mabrey. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1994 Revision. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Szaro, R.C. and P.H. Albers. 1977. Effects of External Applications of No. 2 Fuel Oil on Common Eider Eggs. Pp. 164-167. In: D.A. Wolfe (Ed). Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms. Pergamon Press, New York.
- Szaro, R.C., M.P. Dieter, G.H. Heinz, and J.F. Ferrell. 1978. Effects of Chronic Ingestion of South Louisiana Crude Oil on Mallard Ducklings. Environmental Research 17:426-436.
- Talmadge, S.S. and B.T. Walton. 1991. Small Mammals as Monitors of Environmental Contaminants. Reviews of Environ. Contam. Toxicol. 119:47-145.
- Travis, C.C. and A.D. Arms. 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environ. Sci. Technol. 22(3):271-274.
- Tucker, R.K. and J.S. Leitzke. 1979. Comparative Toxicology of Insecticides for Vertebrate Wildlife and Fish. Pharmac. Ther. 6:167-220.
- U.S. Air Force. 1991. Handbook to Support the Installation Restoration Program (IRP) Statements of Work. Volume 1, Remedial Investigation/Feasibility Studies (RI/FS). Human Systems Division, Brooks Air Force Base, Texas.
- U.S. Air Force. 1993. Sampling and Analysis Plan for DEW Line and Cape Lisburne Radar Stations. Prepared for USAF Center for Environmental Excellence, Environmental Restoration Program Office, Brooks AFB, Texas. Prepared by ICF Technology Inc.
- U.S. Air Force. 1996. Final Point Barrow RI/FS Report. Prepared for USAF Center for Environmental Excellence, Environmental Restoration Program Office, Brooks AFB, Texas. Prepared by ICF Technology Inc. 11 October 1995.
- U.S. Army Corps of Engineers (USACOE). 1991. Baseline Risk Assessment for Eight Selected Study Areas at Aberdeen Proving Ground. Appendix C, Draft Document.
- U.S. Environmental Protection Agency (EPA). 1976. Quality Criteria for Water. Office of Water and Hazardous Materials. Washington, D.C.

- U.S. Environmental Protection Agency. 1985. Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Iron. Office of Water Regulations and Standards. Washington, D.C.
- U.S. Environmental Protection Agency. 1986a. Guidelines for Carcinogen Risk Assessment. Federal Register 51:33992-34013.
- U.S. Environmental Protection Agency. 1986b. Guidelines for Health Risk Assessment of Chemical Mixtures. Federal Register 51:34014-34025.
- U.S. Environmental Protection Agency. 1986c. Quality Criteria for Water. Office of Water Regulations and Standards, Washington D.C. EPA 440/5-86-001.
- U.S. Environmental Protection Agency. 1989a. Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A. Office of Solid Waste and Emergency Response. Washington, D.C.
- U.S. Environmental Protection Agency. 1989b. Risk Assessment Guidance for Superfund: Volume 2, Environmental Evaluation Manual. Office of Solid Waste and Emergency Response. Washington D.C.
- U.S. Environmental Protection Agency. 1991a. Region 10 Supplemental Risk Assessment Guidance for Superfund. Seattle, Washington. 16 August 1991.
- U.S. Environmental Protection Agency. 1991b. Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals. Office of Solid Waste and Emergency Response. Washington D.C. December 13, 1991.
- U.S. Environmental Protection Agency. 1991c. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. Office of Solid Waste and Emergency Response. Washington D.C. 22 April 1991.
- U.S. Environmental Protection Agency. 1992a. Framework for Ecological Risk Assessment. EPA/630/R-92/001. NTIS #PB93-102192. Washington D.C. February 1992.
- U.S. Environmental Protection Agency. 1992b. Oral reference Doses and Oral Slope Factors for JP-4, JP-5, Diesel Fuel, and Gasoline. Environmental Criterion Assessment Office, Office of Research and Development. Cincinnati, Ohio. March 24, 1992.
- U.S. Environmental Protection Agency. 1992c. Handbook of RCRA Ground-Water Monitoring Constituents: Chemical and Physical Properties. Office of Solid Waste Permits and State Programs Division. September 1992.
- U.S. Environmental Protection Agency. 1994a. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities (OSWER Directive #9355.4-12). Office of Solid Waste and Emergency Response. Washington D.C. July 14, 1994.

- U.S. Environmental Protection Agency. 1994b. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. USEPA Environmental Response Team, Edison, New Jersey. September 26, 1994. Review Draft.
- U.S. Fish and Wildlife Service. 1982. Arctic National Wildlife Refuge Coastal Plain Resource Assessment-Initial report. Baseline Study of Fish, Wildlife and Their Habitats. U.S. Department of the Interior, Anchorage Alaska.
- U.S. Fish and Wildlife Service. 1986. Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix. Fish and Wildlife Technical Report 2. Washington D.C. E.F. Hill and M.B. Camardese.
- University of Alaska, Arctic Environmental information and Data Center. 1978. Kaktovik, pp. 2-29.
- Von Burg, R. 1989. Toxicology Update: Gasoline. Journal of Applied Toxicology 9(3):203-210.
- Von Burg, R. 1993. Evaluation of TPH as a Determinant for Petroleum Hydrocarbon Cleanup in Soil. ICF Kaiser Engineers, Oakland, California.
- Walker, D.A., P.J. Webber, K.R. Everett, and J. Brown. 1978. Effects of Crude and Diesel Oil Spills on Plant Communities at Prudhoe Bay, Alaska, and the Derivation of Oil Spill Sensitivity Maps. Arctic 31(3):242-259.
- Weeks, J.A., G.H. Drendel, R.S. Jagan, T.E. McManus, and P.J. Sczerzenie. 1988. Diesel Oil and Kerosene Background Statement. Prepared by Labat-Anderson, Inc. for the U.S. Department of Agriculture, Forest Service. February.
- White, R.G. and J. Trudell. 1980. Habitat Preference and Forage Consumption by Reindeer and Caribou Near Atkasook, Alaska. Arctic and Alpine Research 12(4):511-529.
- Wilber, C.G. 1980. Toxicology of Selenium: A Review. Clinical Toxicology 17(2):171-230.
- Will, M.E. and G.W. Suter. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1994 Revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.
- Wong, C.K., F.R. Engelhardt, and J.R. Strickler. 1981. Survival and Fecundity of *Daphnia Pulex* on Exposure to Particulate Oil.
- Woodward-Clyde Corporation. 1993. Natural Resources Plan: North Coastal Long Range Radar Sites. Final Draft. Prepared for the United States Air Force.
- Wootton, R.J. 1976. The Biology of the Sticklebacks. Academic Press, New York. 387 pp.

APPENDIX A

RISK CHARACTERIZATION SPREADSHEETS

Diesel Fuel Spill (SS01)	A-1
Garage (SS02)	A-5
Air Terminal Area (SS03)	A-7

TABLE A-1. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
 Endpoint: Noncancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Diesel Fuel Spill (SS01)
 File: SS01SONC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	30	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(ED x 365 days/year)	3,650	17,885	2,190

Chemical	Oral RfD	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/kg-day)			Hazard Quotient	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
DRPH	0.08	3,960	2.32E-04	4.65E-04	4.34E-03	2.91.E-03	6.01E-02
GRPH	0.2	210	1.23E-05	2.47E-05	2.30E-04	6.16E-05	1.27E-03
HAZARD INDEX							0.061

TABLE A-2. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
 Endpoint: Cancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Diesel Fuel Spill (SS01)
 File: SS01SOCA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	30	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(lifetime in days)	25,550	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/kg-day)			Cancer Risk	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
GRPH	0.0017	210	1.76E-06	1.73E-05	1.97E-05	2.99E-09	6.29E-08
CANCER RISK							6E-08

TABLE A-3. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Water Ingestion
 Endpoint: Noncancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Diesel Fuel Spill (SS01)
 File: SS01WANC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	180	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(ED x 365 days/year)	3,650	20,075

Chemical	Oral RfD	Concentration Water (mg/L)	LADD by Receptor Group (mg/kg-day)		Hazard Quotients	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
GRPH	0.2	1.69	2.38E-02	2.38E-02	1.19E-01	1.19E-01
HAZARD INDEX						1.19E-01

TABLE A-4. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Water Ingestions
 Endpoint: Cancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Diesel Fuel Spill (SS01)
 File: SS01WACA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	180	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(lifetime in days)	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Water (mg/L)	ADD by Receptor Group (mg/k-day)		Cancer Risk	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
GRPH	0.0017	1.69	3.40E-03	1.87E-02	5.78E-06	3.18E-05
Benzene	0.028	0.009	1.81E-05	9.96E-05	5.25E-07	2.89E-06
			CANCER RISK			
					6E-06	3E-05

TABLE A-5. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
 Endpoint: Noncancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Garage (SS02)
 File: SS02SONC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	30	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(ED x 365 days/year)	3,650	17,885	2,190

Chemical	Oral RfD	Concentration Soil (mg/kg)	LADD by Receptor Group (mg/kg-day)			Hazard Quotients	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
DRPH	0.08	3,300	1.94E-04	3.87E-04	3.62E-04	2.42E-03	5.00E-02
GRPH	0.2	113	6.63E-06	1.33E-05	1.24E-04	3.32E-05	6.86E-04
Aroclor 1254	0.00002	14	8.22E-07	1.64E-06	1.53E-05	4.11E-02	8.49E-01
HAZARD INDEX						0.044	0.900

TABLE A-6. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
 Endpoint: Cancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Garage (SS02)
 File: SS02SOCA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	30	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(lifetime in days)	25,550	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/k-day)			Cancer Risk	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
GRPH	0.0017	113	9.48E-07	9.29E-06	1.06E-05	1.61E-09	3.38E-08
Aroclor 1254	7.7	14	1.17E-07	1.15E-06	1.32E-06	9.04E-07	1.90E-05
CANCER RISK							2E-05

TABLE A-7. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
 Endpoint: Noncancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Air Terminal Area (SS03)
 File: SS03SONC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	30	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(ED x 365 days/year)	3,650	17,885	2,190

Chemical	Oral RfD	Concentration Soil (mg/kg)	LADD by Receptor Group (mg/k-day)			Hazard Quotients	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
DRPH	0.08	11,000	6.46E-04	1.29E-03	1.21E-02	8.07E-03	1.67E-01
GRPH	0.2	1,200	7.05E-05	1.41E-04	1.32E-03	3.52E-04	7.28E-03
Arsenic	0.0003	9.7	5.69E-07	1.14E-06	1.06E-05	1.90E-03	3.92E-02
HAZARD INDEX						0.010	0.213

TABLE A-8. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Soil Ingestion
 Endpoint: Cancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Air Terminal Area (SS03)
 File: SS03SOCA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult	Native Northern Child
Soil Ingestion Rate	(mg/day)	50	100	200
Exposure Frequency	(days/year)	30	30	30
Exposure Duration	(years)	10	49	6
Conversion Factor	(kg/mg)	0.000001	0.000001	0.000001
Body Weight	(kg)	70	70	15
Averaging Time	(lifetime in days)	25,550	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Soil (mg/kg)	ADD by Receptor Group (mg/kg-day)			Cancer Risk	
			DEW Line Worker	Native Northern Adult	Native Northern Child	DEW Line Worker	Native Northern Adult/Child
GRPH	0.0017	1,200	1.01E-05	9.86E-05	1.13E-04	1.71E-08	3.59E-07
Arsenic	1.75	9.7	8.14E-08	7.97E-07	9.11E-07	1.42E-07	2.99E-06
CANCER RISK							3E-06

TABLE A-9. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Water Ingestion
 Endpoint: Noncancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Air Terminal Area (SS03)
 File: SS03WANC.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	180	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(ED x 365 days/year)	3,650	20,075

Chemical	Oral RfD	Concentration Water (mg/L)	LADD by Receptor Group (mg/kg-day)		Hazard Quotient	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
GRPH	0.2	1.126	1.59E-02	1.59E-02	7.93E-02	7.93E-02
HAZARD INDEX						7.93E-02

TABLE A-10. DEW LINE INSTALLATION RISK ASSESSMENT SPREADSHEET

Route: Water Ingestion
 Endpoint: Cancer
 Assumptions: Site-specific
 Installation: Point Barrow
 Site: Air Terminal Area (SS03)
 File: SS03WACA.WK1

Exposure Assumptions		DEW Line Worker	Native Northern Adult
Water Ingestion	(L/day)	2	2
Exposure Frequency	(days/year)	180	180
Exposure Duration	(years)	10	55
Conversion Factor	(kg/mg)	1	1
Body Weight	(kg)	70	70
Averaging Time	(days)	25,550	25,550

Chemical	Carcinogen Oral Slope Factor	Concentration Water (mg/L)	ADD by Receptor Group (mg/kg-day)		Cancer Risk	
			DEW Line Worker	Native Northern Adult	DEW Line Worker	Native Northern Adult
GRPH	0.0017	1.126	2.27E-03	1.25E-02	3.85E-06	2.70E-05
Benzene	0.029	0.083	1.67E-04	9.19E-03	4.84E-06	3.39E-05
			CANCER RISK		9E-06	6E-05

APPENDIX B

TOXICITY PROFILES

DIESEL FUEL (DRPH)	B-1
GASOLINE (GRPH)	B-6
POLYCHLORINATED BIPHENYLS (PCBs)	B-11
ARSENIC	B-14
BENZENE	B-18
1,2-DICHLOROETHANE	B-20

TOXICOLOGY PROFILE FOR DIESEL FUEL (DRPH)

GENERAL DATA

Petroleum fuels are classified into light, middle, and heavy distillate fuels. Gasoline is a typical light distillate fuel while diesel fuel is considered to be a middle distillate material obtained from the distillation of crude oil. Included in this category of middle distillate fuels are jet fuel, kerosene, and #2 fuel oils. Many of the ecological and toxicological effects of these materials are very similar.

The chemical composition of diesel fuel is extremely variable and depends upon the crude oil source, types of processing and refining, blending, and additives employed. These fuels are formulated to meet physical characteristics and not a specific chemical composition. Viscosity and volatility are the principal determinants of the fuel specifications. Diesel #1 is primarily a kerosene type of fuel and produced mainly from straight run middle distillates. Diesel #2 also contains straight run middle distillate but is also blended with straight run kerosene, straight run gas oils, light vacuum distillate, and light thermally and/or catalytically cracked streams (IARC 1989).

Like other petroleum derived fuels, diesel fuels consist of paraffins, olefins, cycloparaffins, isoparaffins, and aromatics as well as additives. Additives can include amyl nitrates, alcohols, n-hexyl nitrate, and octyl nitrate at levels of 0.1 to 0.2 percent (Kirk-Othmer 1984). The total aromatic content of diesel fuel is also variable but levels between 23 and 38 percent have been reported. The average total aromatic is probably in the range of 25 percent. The concentrations of the principal aromatic species of toxicological significance is presented in Table B-1.

FATE AND TRANSPORT

Microbial degradation, plus evaporation, can remove up to 90 percent of the added diesel fuel to soil. Depending on the soil characteristics, the half-life of diesel fuel in soil ranges for one to eight weeks (Song 1988). Volatilization to the air occurs and diesel fuel can be detected by its odor in the air. However, a vapor pressure value could not be located in the literature. Diesel fuel will percolate through the soil and float on the ground water. When spilled onto surface water, diesel fuels can be toxic to fish, waterfowl and algae.

TABLE B-1. REPRESENTATIVE VALUES FOR TOXICOLOGICALLY SIGNIFICANT AROMATIC CONTENT FOR DIESEL FUEL# 2.

COMPONENT	APPROXIMATE CONCENTRATION
Benzene	<50 ppm with an average of 10 ppm
Ethylbenzene	300 ppm
Toluene	200 ppm (max)
Xylene (mixed)	2,400 ppm

(personal communication, Chevron Corp.)

The odor threshold of diesel fuel is approximately 0.8 ppm.

TOXICITY DATA

Human Toxicological Profile

Like other solvents, diesel fuel can be expected to be a central nervous system (CNS) depressant. However, since this fuel is not as volatile as gasoline, breathing vapors at concentrations sufficient to achieve a level of intoxication is not likely at normal temperatures and pressures. An attempt to generate a kerosene (diesel) laden atmosphere only resulted in an ambient concentration of 14 ppm (Carpenter et al. 1976). However, under certain occupational settings like tank cleaning, it may be possible to generate mists or aerosols that can lead to symptoms of overexposure. As with kerosene, these symptoms may include headache, dizziness, weakness, confusion, drowsiness and possibly death (HSDB 1991).

Ingestion of diesel fuel can occur during siphoning, abuse situations, or from contaminated well-water. Ingestion may be accompanied by a burning sensation in the mouth, pharynx and chest, gastrointestinal hypermotility and diarrhea (Gosselin et al. 1984), and possibly nausea and vomiting. A serious complication is the aspiration of hydrocarbons into the lung which produces a potentially-lethal hemorrhagic pneumonitis (Lee and Seymour 1979).

There have been reports of acute renal failure following persons exposed to diesel fuel (Barrientos et al. 1977; Crisp et al. 1979). Kryzanovskij (1971) reports that workers cleaning diesel storage tanks have an increased incidence of disease in general, and specifically cardiovascular disease and bronchitis over control shipyard workers.

Animal Toxicology and Significant Studies

The acute oral and dermal LD₅₀ of diesel fuel is in the range of 9 ml/kg body weight. Eye irritation properties were minimal, but the primary skin irritation score of a marketplace sample was 6.8 indicating that this material is a strong skin irritant (Beck et al. 1982). Chronic skin contact can be expected to produce defatting, fissuring and cracking. There are no readily available reports on hypersensitivity response to diesel fuels can be expected to occur since products on either side of diesel fuels distillation range have been reported to produce hypersensitivity reactions (Beck et al. 1982). Dermal absorption of gasoline is unlikely to result in systemic toxicity, but chronic poisoning of the readily absorbable alkyl lead additives is possible.

Exposure of CD-1 mice to diesel vapor for eight hours per day on five consecutive days resulted in a decrement of performance on the roto-rod test, square box activity test and hot plate test. However, the corneal reflex and inclined plane test was unaffected. General observations noted vasodilation, ataxia, poor grooming and in some cases tremor (Kainz and White 1982).

Exposure of rats to aerosolized diesel fuel at concentrations up to 6 mg/L produced direct toxic effects on the lungs but did not produce any neurotoxicity (Dalbey et al. 1987).

Reproductive Toxicity

Female rats were exposed 6 hours per day to air concentrations of 0, 100, and 400 ppm during days 6 through 15 of gestation. Neither jet fuel or No. 2 fuel oil produced any significant detrimental effects on the reproductive parameters of the experimental animals (Beliles and Mecler 1982). Neither Jet Fuel A or diesel fuel at exposure levels of 400 ppm, 6 hrs per day, 5 day per week for 8 weeks reduced the fertility of CD-1 male mice (API 1980a,b).

Genotoxicity

Kerosene, jet fuel and diesel fuel all tested negatively in the standard Ames bioassay. However, the "Modified Ames Assay" (Blackburn et al. 1988) on two straight run gas oils did demonstrate mutagenicity. (Straight run gas oil can be considered similar to diesel oils.) Diesel fuel was also negative in the mouse lymphoma assay but positive on the rat bone marrow cytogenetics assay when administered by intraperitoneal injection (Conaway et al. 1982). Heating oil #2 produced a positive Ames test as well as positive results in two other short term bioassays (Rothman and Emmett 1988). Dominant lethal testing of Jet fuel A and diesel fuel was negative at 400 ppm to male CD-1 mice (API 1980a,b).

Carcinogenicity

In a classical mouse skin painting bioassay, all petroleum fractions derived from a crude oil source that boiled between 120 and 700°F showed a low level of tumorigenic activity (Lewis et al. 1982). Home heating oil also showed a low level of tumorigenicity in a more recent mouse skin painting assay (Witschi et al. 1987).

In a case referent study, Seimietycki et al. (1987) reported an increase of several specific cancers associated with exposures to different petroleum products. Leaded gasoline was associated with stomach cancer; aviation gasoline with kidney cancer; diesel fuel with non adenocarcinoma of the lung and prostate cancer and mineral spirits with squamous cell lung cancer. However not all parameters of concern were properly controlled, excluded or assessed making conclusions from this study inappropriate.

IARC (1989) has classified diesel fuel as having limited evidence of carcinogenicity in animals. Light diesel fuels are not classifiable as to their carcinogenicity to humans (Group 3).

REGULATIONS AND STANDARDS

Neither the American Conference of Governmental Industrial Hygienists (ACGIH) nor OSHA have recommended or established permissible exposure standards (PELs) for diesel fuels. However, NIOSH, has recommended a 10 hour time-weighted average of 100 mg/m³ or 14 ppm for kerosene (NIOSH 1977). Because of the complexity and variability in composition, OSHA regulates the toxic components by their respective PELs (i.e., n-hexane, benzene, etc.).

Diesel fuels, as such, are not mentioned in HEAST (1990) nor identified for a specific cancer Potency Factor (CPF) or reference dose (RfD). However, individual components such as benzene, other aromatics and for n-hexane having CPF or RfD values should be evaluated by themselves.

REFERENCES

- API. 1980a. Mutagenicity Evaluation of Jet Fuel A in the Mouse Dominant Lethal Assay. Final Report. Litton Bionetics Inc. Proj. No. 21141-03. American Petroleum Institute Medical Research Publications, Washington, D.C.
- API. 1980b. Mutagenicity Evaluation of Diesel Fuel in the Mouse Dominant Lethal Assay. Final Report. Litton Bionetics Inc. Proj. No. 21141-04. American Petroleum Institute Medical Research Publications, Washington, D.C.

- Barrientos, A., M.T. Ortuno, and J.M Morales et al. 1977. Acute Renal Failure After Use of Diesel Fuel as a Shampoo. *Arch. Intern. Med.* 137:1217-1219.
- Beck, L.S., D.I. Hepler, and K.L. Hansen. 1982. The Acute Toxicology of Selected Petroleum Hydrocarbons. In: *Proceedings of the Symposium on The Toxicology of Petroleum Hydrocarbons*. H.N. MacFarland et al. (Editors), American Petroleum Institute, Publisher. Washington, D.C. May.
- Beliles, R.P. and F.J. Mecler. 1982. Inhalation Teratology of Jet Fuel, Fuel Oil and Petroleum Naphtha in Rats. In: *Proceedings of the Symposium on The Toxicology of Petroleum Hydrocarbons*. H.N. MacFarland et al. (Editors), American Petroleum Institute, Publisher. Washington, D.C. May.
- Blackburn, G.R., R.A. Deitch, and T.A. Roy et al. 1988. Estimation of the Dermal Carcinogenic Potency of Petroleum Fractions Using a Modified Ames Assay. In: *Polynuclear Aromatic Hydrocarbons: A Decade of Progress, Proceedings of the Tenth International Symposium*. M. Cooke and A.J. Dennis, Editors. Battelle Press, Columbus Ohio, 99 83-97.
- Carpenter, C.P., D.L. Geary, and R.C. Meyers et al. 1976. Petroleum Hydrocarbon Toxicity Studies XI. Animal and Human Response to Vapors of Deodorized Kerosene. *Toxicol. Appl. Pharmacol.* 36:443-456.
- Conaway, C.C., C.A. Schreiner, and S.T. Cragg. 1982. Mutagenicity Evaluation of Petroleum Hydrocarbons. In: *Proceedings of the Symposium on The Toxicology of Petroleum Hydrocarbons*. H.N. MacFarland et al. (Editors), American Petroleum Institute, Publisher. Washington, D.C. May.
- Crisp, A.J., A.K. Bhalla, and B.I. Hoffbrand. 1979. Acute Tubular Necrosis After Exposure to Diesel Oil. *Brit. Med J.* 2:177-178.
- Dalbey, W., M. Henry, and R. Holmberg et al. 1987. Role of Exposure Parameters in the Toxicity of Aerosolized Diesel Fuel in the Rat. *J. Appl. Toxicol.* 7:265-275.
- Gosselin, R.E., R.P. Smith, and H.C. Hodge. 1984. *Clinical Toxicology of Commercial Products*. 5th Ed. Baltimore, Maryland: Williams & Wilkins.
- HEAST. 1990. Health Effects Assessment Summary Tables, Office of Emergency and Remedial Response, Environmental Protection Agency. OERR 9200 6-303, (90-4).
- HSDB. 1991. Hazardous Substances Data Bank. National Library of Medicine. Washington, D.C.
- IARC. 1989. Monographs on the Evaluation of Carcinogenic Risks to Humans. Occupational Exposures in Petroleum Refining; Crude Oil and Major Petroleum Fuels. International Agency for Research on Cancer, Lyon France. Vol 45.

- Kainz, R.J. and L.E. White. 1982. Consequences Associated with the Inhalation of Uncombusted Diesel Vapor. In: Proceedings of the Symposium on The Toxicology of Petroleum Hydrocarbons. H.N. MacFarland et al. (Editors), American Petroleum Institute, Publisher. Washington, D.C. May.
- Kirk Othmer. 1984. Diesel Fuel. In: Kirk-Othmer Encyclopedia of Chemical Technology. F. Mark, M. Grayson, and D. Eckroth et al., Eds. 3rd Ed. John Wiley and Sons, New York.
- Kryzanovskij, N.V. 1971. Occupational Health Conditions Associated with the Cleaning of Oil Tankers and Their Effect on Worker's Health. Gig. Tr. Prof. Zabol. 15:14-17.
- Lee T. and W. Seymour. 1979. Pneumonitis Caused by Petrol Siphoning. (Letter). The Lancet 8134:149.
- Lewis, S.C., R.W. King, S.T. Cragg, and D.W. Hillman. 1982. Skin Carcinogenic Potential of Petroleum Hydrocarbons. 2. Carcinogenesis of Crude Oil, Distillate Fractions and Chemical Class Subfractions. In: Proceedings of the Symposium on The Toxicology of Petroleum Hydrocarbons. H.N. MacFarland et al. (Editors), American Petroleum Institute, Publisher. Washington, D.C. May.
- NIOSH. 1977. Criteria for a Recommended Standard...Occupational Exposure to Refined Petroleum Solvents. National Institute for Occupational Safety and Health, Cincinnati, Ohio. NIOSH Publication #77-192.
- Rothman, N. and E.A. Emmett. 1988. The Carcinogenic Potential of Selected Petroleum-Derived Products. Occup. Med.: State Art Rev. 3:475-482.
- Siemiatycki, J., R. Dewar, and L. Nadon et al. 1987. Associations Between Several Sites of Cancer and Twelve Petroleum Derived Liquids. Scan. J. Work Environ. Health. 13:493-504.
- Song, H.G. 1988. Petroleum Hydrocarbons in Soil: Biodegradation and Effects on the Microbial Community. Ph.D. Thesis, University of Medicine and Dentistry of New Jersey.
- Witschi, H.P., L.H. Smith, and E.L. Frome et al. 1987. Skin Tumorigenic Potential of Crude and Refined Coal Liquids and Analogous Petroleum Products. Fund. Appl. Toxicol. 9:297-303.

TOXICOLOGY PROFILE FOR GASOLINE (GRPH)

GENERAL DATA

The chemical composition of gasoline is extremely variable, depending upon the crude oil starting material, types of processing and refining, blending and additives employed. Gasolines are formulated to meet fuel performance specifications, not to achieve a specific chemical composition. Volatility must be within a certain range to avoid vapor lock (too high) or sluggish acceleration (too low). In addition, the air-fuel mixture within the cylinder must burn uniformly to prevent "pinging" or "knocking." Often small quantities of butanes, pentanes, organo lead compounds or branched chain hydrocarbons are added to achieve uniform burning rates. McDermott and Killiany (1978) published a detailed gas chromatographic analysis of a premium grade gasoline listing 21 components which accounted for 92 percent of the gasoline vapors (Table B-2). Low-volatility hydrocarbons (high carbon numbers) were not well represented.

Gasoline additives include organic lead (tetraethyl lead and tetramethyl lead) to a concentration of 0.1 g/gallon (7 ppm). Alkyl lead vapors have low volatility (vapor pressure = 0.4 mm Hg) compared to gasoline (400-775 mm Hg), so lead compounds should not be acutely hazardous by inhalation. To prevent accumulation of lead deposits, scavenging agents are added to fuels: ethylene dichloride (EDC) and ethylene dibromide (EDB), usually in a molar ratio EDC/EDB/Pb = 2:2:1.

FATE AND TRANSPORT

Gasoline released into the environment would be expected to evaporate rapidly due to its high vapor pressure (400-477 mm Hg). Studies of gasoline fate when added to soils show that the main clearance mechanism was evaporation which can account for up to 75 percent removal from surface soils (Donaldson 1990). Microbial degradation, plus evaporation, can remove up to 90 percent of the added gasoline (Song 1988). Benzene, a volatile gasoline component of major toxicological interest, has a half life in the air of less than 1 day (Korte and Klein 1982). Gasoline has appreciable water solubility (12 to 16 percent) so it would be transported in ground water and may be found in well water.

TOXICITY DATA

Human Toxicological Profile

Like other solvents, gasoline has potent central nervous system (CNS) depressant activity. Breathing vapors at concentrations achieved during "huffing" or occupational overexposures has led to a variety of neurological symptoms: hallucinations, encephalopathy, ataxia, convulsions, Tourette's Disease, vertigo and nystagmus and peripheral neuropathy (Von Burg 1989). Many of these symptoms may be attributed to n-hexane or alkyl lead compounds.

Ingestion of gasoline can occur during siphoning, abuse situations, or from contaminated well-water. Ingestion is accompanied by a burning sensation in the mouth, pharynx and chest. Swallowing large amounts of gasoline leads to coma and death by respiratory depression. A serious complication is the aspiration of hydrocarbons into the lung which produces a potentially-lethal hemorrhagic pneumonitis (Lee and Seymour 1979).

TABLE B-2. COMPOSITION OF A PREMIUM-GRADE GASOLINE

COMPOUND	VOL %
Propane	0.8
n-Butane	38.1
Isobutane	5.2
n-Pentane	7.0
Cyclopentane	0.7
2,3-DM-butane	0.7
2-M-pentane	2.1
3-M-pentane	1.6
n-Hexane	1.5
M-cyclopentane	1.3
2,4-DM-pentane	0.4
2,3-DM-pentane	0.7
2,2,4-TM-pentane	0.5
Isobutylene	1.1
2-M-1-butane	1.6
c-2-pentene	1.2
2-M-2-butene	1.7
Benzene	0.7
Toluene	1.8
Xylene (m,p,o)	0.5
Total %	92.1

Inhalation exposure to gasoline at concentrations of 1,000 - 5,000 ppm for 15 - 60 minutes can produce CNS depression. A 5-minute exposure to 20,000 ppm (20 percent) has been reported to be fatal (Von Burg 1989).

Three epidemiologic studies of refinery workers showed no increased cancer risk in refinery workers (Hanis et al. 1982; Kaplan 1986; Wong 1987). In an epidemiological study of refinery workers and gasoline handlers, Thomas et al. (1982) found a significant increase in stomach and brain cancer with a trend to increased leukemia and cancer of the skin, prostate and pancreas.

Animal Toxicology and Significant Studies

The acute dermal LD₅₀ of gasoline in rabbits is reported to be <5 ml/kg (Von Burg 1989). Liquid gasoline is considered a primary skin irritant because of the defatting and fissuring which occurs upon repeated contact. Hypersensitivity response to gasoline can occur. Dermal absorption of gasoline is unlikely to result in systemic toxicity, but chronic poisoning of the readily absorbable alkyl lead additives is possible. Gasoline is acutely irritating to the eye, animal studies indicate no effect lasting longer than seven days.

MacFarland (1982), reported on a chronic inhalation study of gasoline in Fischer 344 rats and B6C3F₁ mice. Exposure levels were 0, 67, 292, and 2,056 ppm for 6 hours/day, 5 days/week for 103 to 113 weeks. Male (but not female) rats exhibited a progressive renal tubular disease and renal carcinomas in all dose groups; renal effects in mice were within the expected range of control. High dose female mice had an increased incidence of hepatocellular tumors (48 percent), but the spontaneous incidence of these tumors is also high (14 percent); males showed no increase (44 percent high dose vs. control 45 percent).

Reproductive Toxicity

Male rats exposed intermittently to about 650 ppm unleaded petrol for 2 months showed endocrine changes which were attributed to stress. The offspring of pregnant females exposed to 0, 400, and 1,600 ppm unleaded gasoline for 6 hours per day on days 6-15 of gestation did not show any teratogenic or fetotoxic effects. Mental retardation has been reported among the offspring of gasoline-sniffing mothers.

Genotoxicity

Negative results were observed with several common fuels when tested in the Ames Salmonella typhimurium assay, mouse lymphoma, and the rat bone marrow chromosomal aberration assay (Lebowitz et al. 1979). Unleaded gasoline did not induce unscheduled DNA synthesis in the male rat kidney at doses known to be nephrotoxic.

Carcinogenicity

As indicated earlier, chronic gasoline exposures produces renal tumors in rats.

COMPOUND CAS NO.	ACGIH TLV ppm	RfD (inhal) mg/kg/day	RfD (oral) mg/kg/day	SLOPE FACTOR (inhale) mg/kg/day	SLOPE FACTOR (oral) mg/kg/day
Benzene 71-43-2	0.1	N/A	N/A	2.9E-2	2.9E-2
Ethylene dibromide 106-93-4	A2 ^a	N/A	N/A	7.6E-1	8.5E+1
Ethylene dichloride 107-06-2	10	N/A	N/A	9.1E-2	9.1E-2
n-Hexane 110-54-3	50	6E-1	2E-1	N/A	N/A
Tetraethyl lead 78-00-2	0.1 ^b	1E-7	2.9E-8	N/A	N/A

^a A2 - Substance classed as a suspected human carcinogen, no ACGIH TLV listed.
^b mg/m³, not ppm.

REGULATIONS AND STANDARDS

The American Conference of Governmental Industrial Hygienists (ACGIH 1990) adopted a threshold limit value (TLV) of 300 ppm (mg/m³) for gasoline vapors. Because of the complexity and variability in composition, OSHA has no standard but regulates the toxic components by their respective PELs (i.e., n-hexane, benzene, alkyl lead).

Gasoline as such is not mentioned in HEAST (1990) as having a specific cancer slope factor (CSF) or reference dose (RfD). However, individual components such as benzene, other aromatics, and n-hexane that have CSF or RfD values should be evaluated individually.

REFERENCES

- ACGIH. 1990. Threshold Limit Values for Chemical Substances and Biological Exposure Indices for 1990-1991. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists.
- Donaldson, S.G. 1990. Volatilization of Gasoline from Contaminated Soil. M.S. Thesis, University of Reno.
- Hanis, N.M., T.M. Holmes, L.G. Shallenberger, and K.E. Jones. 1982. Epidemiologic Study of Refinery and Chemical Plant Workers. J. Occup. Med. 24:203-212.

- HEAST. 1990. Health Effects Assessment Summary Tables, Environmental Protection Agency. Office of Emergency and Remedial Response. EPA, OERR 9200 6-303, (90-4).
- Kaplan, S. 1986. Update of a Mortality Study of Workers in Petroleum Refineries. J. Occup. Med. 28:514-516.
- Korte, F. and W. Klein. 1982. Degradation of Benzene in the Environment. Ecotox. Environ. Safety 6:311-327.
- Lee, T. and W. Seymour. 1979. Pneumonitis Caused by Petrol Siphoning. Lancet 8134:149.
- Lebowitz, H., D. Brusick, and D. Matheson et al. 1979. Commonly Used Fuels and Solvents Evaluated in a Battery of Short-Term Bioassays. Environ. Mutagen. 1:172-173.
- MacFarland, H.N. 1982. Chronic Gasoline Toxicology. In: Proceedings of the Symposium: The Toxicology of Petroleum Hydrocarbons, American Petroleum Institute, Washington, D.C.
- McDermott, H. and S. Killiany. 1978. Quest for a Gasoline TLV. Am. Ind. Hyg. Assoc. J. 39:110-117.
- Song, H.G. 1988. Petroleum Hydrocarbons in Soil: Biodegradation and Effects on the Microbial Community. Ph.D. Thesis, University of Medicine and Dentistry of New Jersey.
- Thomas, T.L., R.J. Waxweiler, and R. Moure-Eraso et al. 1982. Mortality Patterns Among Workers in Three Texas Oil Refineries. J. Occup. Med. 24:135-141.
- Wong, O. 1987. An Industry Wide Mortality Study of Chemical Workers Occupationally Exposed to Benzene. Br. J. Ind. Med. 44:365-381.
- Von Burg, R. 1989. Toxicology Update for Gasoline. J. Appl. Toxicol. 9:203-210.

POLYCHLORINATED BIPHENYLS (PCBs)

PCBs are complex mixtures of chlorinated biphenyls. The commercial PCB mixtures that were manufactured in the United States were given the trade name of "Aroclor." Aroclors are distinguished by a four-digit number (for example, Aroclor 1260). The last two digits in the Aroclor 1200 series represent the average percentage by weight of chlorine in the product.

PCBs are readily and extensively absorbed through the gastrointestinal tract and somewhat less readily through the skin; PCBs are presumably readily absorbed from the lungs, but few data are available that experimentally define the extent of absorption after inhalation (EPA 1985). Studies have found oral efficiency on the order of 75 to >90 percent in rats, monkeys and ferrets (Albro and Fishbein 1972; Allen et al. 1974; Tanabe et al. 1981; Bleavens et al. 1984; Clevenger et al. 1989). PCBs distribute preferentially to adipose tissue and concentrate in human breast milk due to its high fat content (ATSDR 1991). Dermatitis and chloracne (a disfiguring and long-term skin disease) have been the most prominent and consistent findings in studies of occupational exposure to PCBs. Several studies examining liver function in exposed humans have reported disturbances in blood levels of liver enzymes. Reduced birth weights, slow weight gain, reduced gestational ages, and behavioral deficits in infants were reported in a study of women who had consumed PCB-contaminated fish from Lake Michigan (EPA 1985). Reproductive, hepatic, immunotoxic, and immunosuppressive effects appear to be the most sensitive end points of PCB toxicity in nonrodent species, and the liver appears to be the most sensitive target organ for toxicity in rodents (EPA 1985). For example, adult monkeys exposed to dietary concentrations of 0.028 mg/kg-day Aroclor 1016 for approximately 22 months showed no evidence of overt toxicity; however, the offspring of these monkeys exhibited decreased birth weight and possible neurological impairment (Barsotti and Van Miller 1984; Levin et al. 1988; Schantz et al. 1989, 1991). A number of studies have suggested that PCB mixtures are capable of increasing the frequency of tumors including liver tumors in animals exposed to the mixtures for long periods (Kimbrough et al. 1975; NCI 1978; Schaeffer et al. 1984; Norback and Weltman 1985). Studies have suggested that PCB mixtures can act to promote or inhibit the action of other carcinogens in rats and mice (EPA 1985). It is known that PCB congeners vary greatly in their potency in producing biological effects, such as cancer however, EPA (1995) generally considers Aroclor 1260 to be representative of all PCB mixtures for the evaluation of carcinogenic effects. There is some evidence that mixtures containing highly chlorinated biphenyls are more potent inducers of hepatocellular carcinoma in rats than are mixtures containing less chlorine by weight (EPA 1995).

EPA (1995) classified PCBs as a Group B2 agent (Probable Human Carcinogen) based on sufficient evidence in animal bioassays and inadequate evidence from studies in humans. The EPA (1995) calculated an oral cancer potency factor of $7.7 \text{ (mg/kg/day)}^{-1}$ for PCBs based on the incidence of hepatocellular carcinomas (91%) and neoplastic nodules (4%) in female Sprague-Dawley rats exposed to a diet containing Aroclor 1260 as reported in a study by Norback and Weltman (1985). In the same study, males exhibited a much lower incidence of malignant tumors but a higher incidence of benign tumors (neoplastic nodules). EPA (1995) also calculated a slope factor of $5.7 \text{ (mg/kg-day)}^{-1}$ for malignant tumors alone, which is supported by a risk estimate based on the data of Kimbrough et al. (1975). EPA (1995) derived an oral RfD of $7 \times 10^{-5} \text{ mg/kg/day}$ for Aroclor 1016 based on a 21.8 month oral study conducted in monkeys (Barsotti and Van Miller 1984; Levin et al. 1988; Schantz et al. 1989, 1991). A no-observed-adverse-effect level of 0.25 ppm (0.007 mg/kg/day) for decreased birth weight in offspring was identified from these studies. A safety factor of 100 (3 to account for interspecies extrapolation,

3 to account for sensitive individuals, 3 to account for limitations in the database, and 3 to account for extrapolation from a subchronic to a chronic RfD) was used to calculate the RfD.

EPA (1995) derived an oral RfD of 2×10^{-5} mg/kg/day for Aroclor 1254 based on clinical and immunological studies conducted in monkeys that received oral doses in gelatin capsules for more than five years (Arnold et al. 1994a,b; Tryphonas et al. 1989, 1991a,b; cited in EPA 1995). The critical effects observed in monkeys included ocular exudate, inflamed and prominent Meibomian glands, distorted growth of finger and toe nails, and a decreased antibody (IgG and IgM) response to sheep erythrocytes. To derive the oral RfD, an uncertainty factor of 300 was applied to the LOAEL from the cited studies. The uncertainty factor accounts for the variability in toxic responses among human individuals, for the extrapolation of a study in monkeys to potential exposures of humans, and for the use of a LOAEL instead of a NOAEL.

REFERENCES

- Agency for Toxic Substances and Disease Registry (ATSDR). 1991. Toxicological Profile for Selected PCBs (Aroclor 1260, -1254, -1248, -1242, -1232, -1221, and 1016). U.S. Department of Health and Human Services. Draft for Public Comment. October 1991.
- Albro, P.W. and L. Fishbein. 1972. Intestinal Absorption of Polychlorinated Biphenyls in Rats. *Bull. Environ. Contam. Toxicol.* 8:26-31.
- Allen, J.R., D.H. Norback, and I.C. Hsu. 1974. Tissue Modifications in Monkeys as Related to Absorption, Distribution, and Excretion of Polychlorinated Biphenyls. *Arch. Environ. Contam. Toxicol.* 2:86-95.
- Barsotti, D.A. and J.P. Van Miller. 1984. Accumulation of a Commercial Polychlorinated Biphenyl Mixture (Aroclor 1016) in Adult Rhesus Monkeys and Their Nursing Infants. *Toxicology* 30:31-44.
- Bleavins, M.R., W.J. Breslin, and R.J. Aulerich et al. 1984. Placental and Mammary Transfer of a Polychlorinated Biphenyl Mixture (Aroclor 1254) in the European Ferret (*Mustela putorius furo*). *Environ. Toxicol. Chem.* 3:637-644.
- Clevenger, M.A., S.M. Roberts, and D.L. Lattin et al. 1989. The Pharmacokinetics of 2,2', 5,5'-Tetrachlorobiphenyl and 3,3', 4,4'-Tetrachlorobiphenyl and its Relationship to Toxicity. *Toxicol. Appl. Pharmacol.* 100:315-327.
- Environmental Protection Agency (EPA). 1985. Health Effects Criteria Document on Polychlorinated Biphenyls. Final Draft. Office of Drinking Water, Washington.
- Environmental Protection Agency (EPA). 1995. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, Ohio.
- Kimbrough, R.D., R.A. Squire, R.E. Linder, J.D. Strandberg, R.J. Montali, and V.W. Burse. 1975. Induction of Liver Tumors in Sherman Strain Female Rats by Polychlorinated Biphenyl Aroclor 1260. *J. Natl. Cancer Inst.* 55:1453.
- Levin, E.D., S.L. Schantz, and R.E. Bowman. 1988. Delayed Spatial Alteration Deficits Resulting from Perinatal PCB Exposure in Monkeys. *Arch. Toxicol.* 62:267-273.

- National Cancer Institute (NCI). 1978. Bioassay of Aroclor 1254 for Possible Carcinogenicity. Cas. No. 27323-18-8. NCI Carcinogenesis Technical Report Series No. 38. DHEW (NIH) Publication No. 78-838.
- Norback, D.H. and R.H. Weltman. 1985. Polychlorinated Biphenyl Induction of Hepatocellular Carcinoma in the Sprague-Dawley Rat. Environ. Health Perspect. 1:134-143.
- Schaeffer, E., H. Greim, and W. Goessner. 1984. Pathology of Chronic Polychlorinated Biphenyl (PCB) Feeding in Rats. Toxicol. Appl. Pharmacol. 75:278-288.
- Schantz, S.L., E.D. Levin, and R.E. Bowman et al. 1989. Effects of Perinatal PCB Exposure on Discrimination-Reversal Learning in Monkeys. Neurotoxicol. Teratol. 11:243-250.
- Schantz, S.L., E.D. Levin, and R.E. Bowman. 1991. Long-Term Neurobehavioral Effects of Perinatal Polychlorinated Biphenyl (PCB) Exposure in Monkeys. Environ. Toxicol. Chem. 10:747-756.
- Tanabe, S., Y. Nakagawa, and R. Tatsukawa. 1981. Absorption Efficiency and Biological Half-Life of Individual Chlorobiphenyls in Rats Treated with Kanechlor Products. Agric. Biol. Chem. 45:717-726.

ARSENIC

Chronic Exposure

Chronic arsenic poisoning of humans (by drinking water ingestion) is associated with increased risk of non-melanoma, typically non-lethal, skin cancer and a peripheral vascular disorder that results in gangrene of the extremities, known as blackfoot disease (Tseng 1977). Additionally, there is strong evidence to suggest that ingested inorganic arsenic causes cancers of the bladder, kidney, lung, and liver, and possibly other sites (Bates 1992; Chen 1992; Chen 1986). Hyperpigmentation and keratosis are also associated with chronic arsenic poisoning (Neubauer 1947) and arsenic can produce peripheral and central nervous system toxicity, precancerous dermal lesions, and cardiovascular damage (EPA 1984; Tseng 1977). Arsenic is embryotoxic, fetotoxic, and teratogenic in several animal species (EPA 1984). No evidence of reproductive toxicity was found (Calabrese 1991). Epidemiological studies of workers in smelters and in plants manufacturing arsenical pesticides have shown inhalation of arsenic is strongly associated with lung cancer and less so, with hepatic angiosarcoma (EPA 1984).

Paradoxically, there is substantial evidence that establishes arsenic in trace levels, as an essential human nutrient. Arsenic deficiency has been shown to depress growth and impair reproduction in rats, minipigs, chickens, and goats (EPA 1988; NRC 1989).

Acute Exposure

Acute exposure in humans by ingestion of metallic arsenic has been associated with gastrointestinal effects, hemolysis, and neuropathy (EPA 1984).

Absorption

Both inorganic and organic forms of arsenic are readily absorbed via oral and inhalation routes. Soluble forms are more readily absorbed than insoluble forms (EPA 1984). Approximately 95 percent of soluble inorganic arsenic administered to rats is absorbed from the gastrointestinal tract (Coulson 1935; Ray-Bettley 1975). Approximately 70 to 80 percent of arsenic deposited in the respiratory tract of humans has been shown to be absorbed (Holland 1959). Dermal absorption is not significant (EPA 1984). At mining sites, arsenic is expected to occur naturally in mineral assemblages with considerably lower bioavailability than would be expected in soluble inorganic arsenic salts (Davis 1992).

Metabolism

Methylation of arsenic to a less toxic, more rapidly excreted chemical species provides an effective detoxification mechanism *in vivo*. In humans, this system may become saturated at daily oral intake rates greater than 250-1,000 $\mu\text{g/day}$. For this reason, the dose-response curve for arsenic, for carcinogenicity and systemic toxicity, may not be completely linear, i.e. a portion of the dose-response curve exists over which increases in dose do not result in comparable increases in physiological response (Petito 1990).

Risk Assessment Values

EPA's Weight-of-Evidence Classification places arsenic as a Group A, Human Carcinogen (EPA 1994a).

Oral Cancer Risk EPA (1994a, 1988) derived an oral unit risk of $5 \times 10^{-5} (\mu\text{g/l})^{-1}$ and an oral slope factor of $1.5 (\text{mg/kg/day})^{-1}$, assuming a 70 kilogram individual ingests 2 liter of water per day. The oral drinking water unit risk was based on an epidemiological study (Tseng 1977) which indicated an increased incidence of skin cancer in individuals exposed to arsenic in drinking water. An oral Maximum Contaminant Level/Maximum Contaminant Level Goal (MCL/MCLG) of 0.05 mg/l has been established for arsenic. Unlike most carcinogens, the MCLG for arsenic has not been set at zero because of the belief that it is an essential nutrient. Ambient water quality criteria for 10^{-6} excess cancer risk by water and fish consumption has been set at 0.148 $\mu\text{g/l}$ and, for fish consumption only, 0.14 $\mu\text{g/l}$ (EPA 1995).

Oral Systemic Toxicity An oral chronic and subchronic reference dose (RfD) of $3 \times 10^{-4} \text{ mg/kg/day}$ was calculated for arsenic based on incidence of keratosis and hyperpigmentation in humans (Tseng 1977; EPA 1994, 1995). An uncertainty factor of 3 and a modifying factor of 1 was used to derive both the chronic and subchronic oral RfDs. Applying EPA's RfD methodology, strong scientific arguments can be made for various values within a factor of 2 or 3 of the recommended RfD (i.e. 0.1 - 0.8 $\mu\text{g/kg/day}$) (EPA 1994a).

Inhalation Cancer Risk The inhalation unit risk for arsenic is $4.3 \times 10^{-3} (\mu\text{g/m}^3)^{-1}$. The inhalation unit risk is the geometric mean value of unit risks derived from four occupational studies on two different exposure populations (EPA 1984).

Occupational Values The National Institute of Occupational Safety and Health (NIOSH) has set an Immediately Dangerous to Life or Health (IDLH) level for arsenic at 5 mg/m^3 (NIOSH 1994). The IDLH value represents a maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects (NIOSH 1994). The highest in concentration of arsenic that should not be exceeded over a period of 15 minutes is 0.002 mg/k^3 (NIOSH 1995).

Ambient Air Values Ambient Air Level Goals (AALGs), which are similar in concept to drinking water MCLGs, have been calculated for arsenic (Calabrese 1991). These reference levels are chronic ambient air exposure concentrations on a Time-Weighted Average (TWA) basis, below which no adverse health effect is expected to occur in a general population of humans, including sensitive subgroups. The AALG based on developmental toxicity is 0.014 $\mu\text{g/m}^3$ (24-hour TWA) and the AALG based on 10^{-6} excess cancer risk is $4.66 \times 10^{-5} \mu\text{g/m}^3$ (annual TWA).

Chemistry

Arsenic is difficult to characterize as a single species because it has complex chemistry. It may be trivalent or pentavalent and is widely distributed in nature. The most common inorganic trivalent arsenic compounds are arsenic trioxide, sodium arsenite, and arsenic trichloride. Pentavalent inorganic compounds are arsenic pentoxide, arsenic acid, and arsenate. Organic compounds may also be trivalent or pentavalent, such as arsanilic acid or in methylated forms as a consequence of biomethylation by organisms in soil and in both fresh and marine aquatic environments (Amdur 1991).

REFERENCES

- Bates, M.N., A.H. Smith, and C. Hopenhayn-Rich. 1992. Arsenic Ingestion and Internal Cancers: A Review. *Am. J. Epidemiol.* 135:462-476.

- Calabrese, E.J. and E.M. Kenyon. 1991. Air Toxics and Risk Assessment. Chelsea, Michigan: Lewis Publishers, Inc.
- Chen, C.J. and C.W. Chen. 1992. Cancer Potential in Liver, Lung, Bladder, and Kidney Due to Ingested Inorganic Arsenic in Drinking Water. Br. J. Cancer 66:000-000 (sic).
- Chen, C., Y. Chuang, S. You, T. Lin, and H. Wu. 1986. A Retrospective Study on Malignant Neoplasms of Bladder, Lung, and Liver in Blackfoot Disease Endemic Area in Taiwan. Br. J. Cancer 53:399-405.
- Coulson, E.J., R.E. Remington, and K.M. Lynch. 1935. Metabolism in the Rat of the Naturally Occurring Arsenic of Shrimp as Compared with Arsenic Trioxide. J. Nutr. 10:255-270.
- Davis, A., M.V. Ruby, and P.D. Bergstrom. 1992. Bioavailability of Arsenic and Lead in Soils from the Butte, Montana Mining District. Environ. Sci. Technol. 26:461-468.
- Environmental Protection Agency (EPA). 1984. Health Assessment Document for Inorganic Arsenic. Office of Health and Environmental Assessment, Washington D.C. EPA 600/8-83-021F.
- Environmental Protection Agency (EPA). 1988. Special Report on Ingested Inorganic Arsenic Skin Cancer: Nutritional Essentiality. Risk Assessment Forum. U.S. Environmental Protection Agency, Washington, D.C. EPA/625/3-87/013F. July 1988.
- Environmental Protection Agency (EPA). 1994. Health Effects Assessment Summary Tables. Prepared by Office of Health and Environmental Assessment, Environmental Assessment and Criteria Office, Cincinnati, Ohio, for the Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Washington, D.C.
- Environmental Protection Agency (EPA). 1995. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, Ohio.
- Holland, R.H., M.S. McCall, and H.C. Lanz. 1959. A Study of Inhaled Arsenic-74 in Man. Cancer Res. 19:1154-1156.
- National Research Council (NRC). 1989. Recommended Dietary Allowances. Washington D.C.: National Academy Press.
- National Institute for Occupational Safety and Health (NIOSH). 1990. NIOSH Pocket Guide to Chemical Hazards. U.S. Department of Health and Human Services, September 1990.
- Neubauer, O. 1947. Arsenical Cancer - A Review. Brit. J. Cancer, 1:192.
- Petito, C.T. and B.D. Beck. 1990. Evaluation of Evidence of Nonlinearities in the Dose-Response Curve for Arsenic Carcinogenesis. Trace Substances in Environmental Health, XXIV:143-176.
- Ray-Bettley, F. and J.A. O'Shea. 1975. The Absorption of Arsenic and its Relation to Carcinoma. Br. J. Dermatol. 92:563-568.

Tseng, W.P. 1977. Effects and Dose-Response Relationships of Skin Cancer and Blackfoot Disease with Arsenic. Environ. Health Perspect. 19:109-119, August, 1977.

BENZENE

Benzene is readily absorbed following oral and inhalation exposure (EPA 1985). The toxic effects of benzene in humans and other animals following exposure by inhalation include central nervous system effects, hematological effects, and immune system depression. In humans, acute exposures to high concentrations of benzene vapors have been associated with dizziness, nausea, vomiting, headache, drowsiness, narcosis, coma, and death (NAS 1976). Chronic exposure (at least 20 years of worker exposure) to benzene vapors (1-100 ppm 8-hour TWA) reduce leukocyte, platelet, and red blood cell counts (EPA 1993). Benzene induced tumors of the zymbal gland, oral cavity, leukemia and lymphoma in rodents chronically exposed by gavage to doses in the range of 25-500 mg/kg/day (Huff et al. 1989; NTP 1986; Maltoni et al. 1989). Many studies have also described a causal relationship between exposure to benzene by inhalation (either alone or in combination with other chemicals) and leukemia in humans (IARC 1982; Rinsky et al. 1981; Ott et al. 1978; Wong et al. 1983).

Applying EPA's criteria for evaluating the overall evidence of carcinogenicity to humans, benzene is classified in Group A (Human Carcinogen) based on adequate evidence of carcinogenicity from epidemiological studies. EPA (1993) derived an oral cancer slope factor of 2.9×10^{-2} (mg/kg/day)⁻¹ and an inhalation unit risk of 8.3×10^{-6} (ug/m³)⁻¹ for benzene. These values were based on several studies in which increased incidence of nonlymphocytic leukemia were observed in humans occupationally exposed to benzene principally by inhalation (Rinsky et al. 1981; Ott et al. 1978; Wong et al. 1983). Equal weight was given to cumulative dose and weighted cumulative dose as well as to relative and absolute risk model forms (EPA 1993). EPA (1993) is currently reviewing both oral and inhalation RfDs for benzene, for which the status is pending.

The National Research Council's Committee on Toxicology has set a one-hour Emergency Exposure Guidance Level (EEGL), for benzene at 50 ppm (200 mg/m³) (NRC 1986). Formerly known as EEL, the EEGL is defined as a ceiling limit for an unpredicted single exposure lasting one to 24 hours, which is expected to be rare in the lifetime of any person. It is designed to avoid substantial decrements in performance during emergencies and takes into account the statistical likelihood of a non-incapacitative, reversible effect in exposed populations (NRC 1986). A health criterion for acute inhalation exposure to benzene of 20 mg/m³ can be derived from the EEGL by combining it with a safety factor of 10 to account for the healthy worker effect, which assumes employed persons are generally healthier than the general population.

REFERENCES

- Environmental Protection Agency (EPA). 1985. Drinking Water Criteria Document for Benzene (Final Draft). Office of Drinking Water, Washington, D.C. April 1985.
- Environmental Protection Agency (EPA). 1993. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, Ohio.
- Huff, J.E., J.K. Haseman, and D.M. Demarini et al. 1989. Multiple-Site Carcinogenicity of Benzene in Fischer 344 Rats and B6C3F1 Mice. Environ. Health Perspect. 82:125-163.

- International Agency for Research On Cancer (IARC). 1982. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Some Aromatic Amines, Anthraquinones and Nitroso Compounds, and Inorganic Fluorides Used in Drinking-Water and Dental Preparations. World Health Organization, Lyon, France. Vol. 27.
- Maltoni, C., B. Conti, and G. Cotti et al. 1989. Benzene: A Experimental Multipotential Carcinogen. Results of Long-Term Bioassays Performed at the Bologna Institute of Oncology. Environ. Health Perspect. 82:109-124.
- National Academy of Science (NAS). 1976. Health Effects of Benzene: A Review Committee on Toxicology, Assembly of Life Sciences. National Research Council, Washington, D.C.
- National Research Council (NRC). 1986. Emergency and Continuous Exposure Guidance Levels for Selected Airborne Contaminants. Volume 6. Prepared by the Committee on Toxicology. National Academy Press, 1986.
- National Toxicology Program (NTP). 1986. NTP-Technical Report Series No. 289. Toxicology and Carcinogenesis Studies of Benzene in F344/N Rats and B6C3F1 Mice (Gavage Studies). Research Triangle Park, North Carolina: U.S. Department of Health and Human Services, Public Health Service, National Institute of Health. NIH publication No. 86-2545.
- Ott, M.G., J.C. Townsend, W.A. Fishbeck, and R.A. Langner. 1978. Mortality Among Individuals Occupationally Exposed to Benzene. Arch. Environ. Health 33:3-10.
- Rinsky, R.A., R.J. Young, and A.B. Smith. 1981. Leukemia in Benzene Workers. Am. J. Ind. Med. 3:217-245.
- Wong, O., R.W. Morgan, and M.D. Whorton. 1983. Comments on the NIOSH Study of Leukemia in Benzene Workers. Technical Report Submitted to Gulf Canada, Ltd., by Environmental Health Associates.

1,2-DICHLOROETHANE

1,2-Dichloroethane (1,2-DCA) is lipophilic and is absorbed through oral, inhalation and dermal exposure. In studies with animals, absorption is rapid and nearly complete by inhalation or oral routes of exposure (Reitz et al. 1980). Effects of acute inhalation exposure in humans include CNS effects such as nausea, irritability, headache, drowsiness and tremors, liver and kidney effects and respiratory distress (ATSDR 1992). Acute oral exposure in humans resulted in adverse liver, kidney and CNS effects. In studies with animals, the immune system is a target of 1,2-DCA toxicity following acute oral exposure. Subchronic exposure of rats given gavage doses of greater than or equal to 240 mg/kg/day resulted in mild hyperplasia and inflammation of the forestomach (NTP 1991). In the same study, neurological effects were manifested as tremors, salivation, emaciation, abnormal posture, ruffled fur and dyspnea (NTP 1991). Chronic inhalation studies with animals also have revealed toxic effects including degeneration of the liver (EPA 1985). 1,2-DCA is not a developmental toxicant in experimental animals except at maternally toxic levels (ATSDR 1992; EPA 1985); however, intermittent exposure of females to 4.7 ppm for 4 months prior to mating followed by inhalation exposure during pregnancy produced a statistically significant increase in embryo mortality (Vozovaya 1977). Additionally, nursing women exposed to 1,2-DCA in the workplace air accumulate the chemical in breast milk (Erikson et al. 1980; Urosova 1953). In long-term oral bioassays sponsored by the National Cancer Institute (NCI 1978), an increased incidence of squamous-cell carcinomas of the forestomach, mammary gland adenocarcinomas, and hemangiosarcomas were observed in rats exposed to 1,2-DCA. Pulmonary adenomas, mammary adenocarcinomas, and uterine endometrial tumors were observed in mice exposed to this chemical.

EPA (1993) has classified 1,2-DCA in Group B2 (Probable Human Carcinogen) based on inadequate evidence of carcinogenicity from human studies and sufficient evidence of carcinogenicity from animal studies. EPA (1993) derived an oral cancer slope factor of $9.1 \times 10^{-2} \text{ (mg/kg/day)}^{-1}$ for 1,2-DCA based on the incidence of hemangiosarcomas in Osborne-Mendel male rats observed in the NCI (1978) gavage study. An inhalation cancer unit risk of $2.6 \times 10^{-5} \text{ (}\mu\text{g/m}^3\text{)}^{-1}$ has also been calculated by EPA (1993) using the same gavage study, and route-to-route extrapolation.

REFERENCES

- Agency for Toxic Substances and Disease Registry (ATSDR). 1992. Toxicological Profile for 1,2-Dichloroethane. U.S. Department of Health and Human Services. Draft for Public Comment. October.
- Environmental Protection Agency (EPA). 1984. Health Effects Assessment for 1,2-Dichloroethane. Environmental Criteria and Assessment Office, Cincinnati, Ohio. September 1984. EPA 540/1-86-002.
- Environmental Protection Agency (EPA). 1985. Health Assessment Document for 1,2-Dichloroethane. Office of Health and Environmental Assessment, Washington, D.C. September 1985. EPA 600/8-84-006F.
- Environmental Protection Agency (EPA). 1993. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, Ohio.

Erickson, M.D., B.S.H. Harris, III, and E.D. Pellizzari et al. 1980. Acquisition and Chemical Analysis of Mother's Milk for Selected Toxic Substances. Report to U.S. EPA, Office of Pesticides and Toxic Substances, Washington, D.C., by Research Triangle Park Institute, RTP, NC. EPA 560/13-80/029 (as cited in ATSDR 1992).

National Cancer Institute (NCI). 1978. Bioassay of 1,2-Dichloroethane for Possible Carcinogenicity. NCI Carcinogenesis Technical Report Series No. 55. Washington, D.C. DHEW (NIH) Publication No. 78-1361.

National Toxicology Program (NTP). 1991. NTP Report on the Toxicity of 1,2-Dichloroethane in F344/N Rats, Sprague-Dawley Rats, Osborne-Mendel Rats and B6C3F Mice (Drinking Water and Gavage Studies). NTP, U.S. Department of Health and Human Services, Public Health Service, National Institute of Health, Research Triangle Park, North Carolina (as cited in ATSDR 1992).

Reitz, R.H., T.R. Fox, and J.Y. Domoradzki et al. 1980. Pharmacokinetics and Macromolecular Interactions of Ethylene Dichloride: Comparison of Oral and Inhalation Exposures. In: B.N. Ames, P. Infante, and R. Reitz, Eds. Ethylene Dichloride: A Potential Health Risk? Cold Spring Harbor, New York: Cold Spring Harbor Laboratory, 135-148 (as cited in ATSDR 1992).

Urosova, T.P. 1953. The Possible Presence of Dichloroethane in Human Milk with Exposure in Industrial Conditions. Gig. Sanit. 18:36-37 (as cited in ATSDR 1992).

Vozovaya, M. 1977. The Effect of Dichloroethane on the Sexual Cycle and Embryogenesis of Experimental Animals. Akusk Ginekol (Moscow) 2:57-59 (as cited in ATSDR 1992).

APPENDIX C
BIOCONCENTRATION FACTOR CALCULATIONS

**BIOCONCENTRATION FACTOR CALCULATIONS for ORGANIC CHEMICALS
at POINT BARROW**

CALCULATION OF B _v FOR ORGANIC CHEMICALS IN SOIL				
COC	log K _{ow}	1.588 - 0.578 log K _{ow}	log B _v	B _v
DRPH	5.30	-1.475	-1.475	0.033
GRPH ^a				
Benzene	2.69	0.033	0.033	1.079
Tetrachloroethene	2.53	0.126	0.126	1.336
Xylenes (total) ^b	2.77	-0.013	-0.013	0.970
Aroclor 1254	6.94	-2.423	-2.423	0.004

^a volatility of GRPH is expected to limit uptake and bioaccumulation

^b log K_{ow} for ortho-xylene used

APPENDIX D

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS for POINT BARROW

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS				
CF = CS*Bv*%V				
INSTALLATION	COC	Bioconcentration	Proportion	COC
Point Barrow	Concentration	Factor	of vegetation	Concentration
SPECIES	Soil/Sediment		in diet	in food
brown lemming	(CS)	(Bv)	(%V)	(CF)
COC	mg/kg	unitless	%	mg/kg
Inorganics				
Iron	0.00	0.004	0.50	0.0000
Lead	120.00	0.045	0.50	2.700
Zinc	150.00	1.500	0.50	112.500
Organics				
DRPH	730.00	0.03	0.50	12.215
GRPH	95.00	NC	0.50	
Toluene	0.11	1.08	0.50	0.059
Xylenes (total)	1.20	0.97	0.50	0.582
Aroclor 1254	4.80	0.004	0.50	0.0091

NC = not calculated

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS for POINT BARROW

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS				
CF = CS*Bv*%V				
INSTALLATION	COC	Bioconcentration	Proportion	COC
Point Barrow	Concentration	Factor	of vegetation	Concentration
SPECIES	Soil/Sediment		in diet	in food
caribou	(CS)	(Bv)	(%V)	(CF)
COC	mg/kg	unitless	%	mg/kg
Inorganics				
Iron	0.00	0.004	0.01	0.0000
Lead	120.00	0.045	0.01	0.054
Zinc	150.00	1.500	0.01	2.250
Organics				
DRPH	730.00	0.03	0.01	0.244
GRPH	95.00	NC	0.01	
Toluene	0.11	1.08	0.01	0.001
Xylenes (total)	1.20	0.97	0.01	0.012
Aroclor 1254	4.80	0.004	0.01	0.0002

NC = not calculated

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS for POINT BARROW

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS				
CF = CS*Bv*%V				
INSTALLATION Point Barrow	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
SPECIES Lapland longspur				
COC				
Inorganics				
Iron	0.00	0.004	0.20	0.0000
Lead	120.00	0.045	0.20	1.080
Zinc	150.00	1.500	0.20	45.000
Organics				
DRPH	730.00	0.03	0.20	4.886
GRPH	95.00	NC	0.20	
Toluene	0.11	1.08	0.20	0.024
Xylenes (total)	1.20	0.97	0.20	0.233
Aroclor 1254	4.80	0.004	0.20	0.0036

NC = not calculated

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS for POINT BARROW

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS				
CF = CS*Bv*%V				
INSTALLATION Point Barrow	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
SPECIES glaucous gull				
COC				
Inorganics				
Iron	0.00	0.004	0.01	0.0000
Lead	120.00	0.045	0.01	0.054
Zinc	150.00	1.500	0.01	2.250
Organics				
DRPH	730.00	0.03	0.01	0.244
GRPH	95.00	NC	0.01	
Toluene	0.11	1.08	0.01	0.001
Xylenes (total)	1.20	0.97	0.01	0.012
Aroclor 1254	4.80	0.004	0.01	0.0002

NC = not calculated

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS for POINT BARROW

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS				
CF = CS*Bv*%V				
INSTALLATION	COC	Bioconcentration	Proportion	COC
Point Barrow	Concentration	Factor	of vegetation	Concentration
SPECIES	Soil/Sediment		in diet	in food
brant	(CS)	(Bv)	(%V)	(CF)
COC	mg/kg	unitless	%	mg/kg
Inorganics				
Iron	0.00	0.004	0.03	0.0000
Lead	120.00	0.045	0.03	0.162
Zinc	150.00	1.500	0.03	6.750
Organics				
DRPH	730.00	0.03	0.03	0.733
GRPH	95.00	NC	0.03	
Toluene	0.11	1.08	0.03	0.004
Xylenes (total)	1.20	0.97	0.03	0.035
Aroclor 1254	4.80	0.004	0.03	0.0005

NC = not calculated

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS for POINT BARROW

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS				
CF = CS*Bv*%V				
INSTALLATION	COC	Bioconcentration	Proportion	COC
Point Barrow	Concentration	Factor	of vegetation	Concentration
SPECIES	Soil/Sediment	(Bv)	in diet	in food
pectoral sandpiper	(CS)	unitless	(%V)	(CF)
COC	mg/kg		%	mg/kg
Inorganics				
Iron	0.00	0.004	1.00	0.0000
Lead	120.00	0.045	1.00	5.400
Zinc	150.00	1.500	1.00	225.000
Organics				
DRPH	730.00	0.03	1.00	24.430
GRPH	95.00	NC	1.00	
Toluene	0.11	1.08	1.00	0.119
Xylenes (total)	1.20	0.97	1.00	1.164
Aroclor 1254	4.80	0.004	1.00	0.0181

NC = not calculated

CONTAMINANT CONCENTRATION IN FOOD CALCULATIONS for POINT BARROW

PLANT UPTAKE AND DIETARY PROPORTION OF VEGETATION CALCULATIONS				
CF = CS*Bv*%V				
INSTALLATION Point Barrow	COC Concentration Soil/Sediment (CS) mg/kg	Bioconcentration Factor (Bv) unitless	Proportion of vegetation in diet (%V) %	COC Concentration in food (CF) mg/kg
SPECIES spectacled eider				
COC				
Inorganics				
Iron	0.00	0.004	0.25	0.0000
Lead	120.00	0.045	0.25	1.350
Zinc	150.00	1.500	0.25	56.250
Organics				
DRPH	730.00	0.03	0.25	6.107
GRPH	95.00	NC	0.25	
Toluene	0.11	1.08	0.25	0.030
Xylenes (total)	1.20	0.97	0.25	0.291
Aroclor 1254	4.80	0.004	0.25	0.0045

NC = not calculated

APPENDIX E
ESTIMATED EXPOSURE EQUATIONS

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

Estimated Exposure = $\left(\frac{[(CF*FI) + (CS*SI*ROA) + (CW*WI)] * .001}{IS} \right) / BW$																				
INSTALLATION		COC	Food	Soil/Sed.		COC	Soil/Sed.	Relative	COC	Water	Percent		ESTIMATED							
Point Barrow		Conc.	Intake	Intake	Conc.	Conc.	Ingestion	Oral	Conc.	Intake	Conver.	Ingested	Body							
SPECIES		Food Items	Rate	%	Soil / Sed.	Soil / Sed.	Rate	Availability	Water	Rate	Units	at Site	Weight							
		(CF)*	(FI)	(CF*FI)	(SI%)	(CS)	(SI)	(ROA)	(CW)	(WI)	(CW*WI)	(IS)	(BW)							
		(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(C)	(D)	(D)*.001	(kg)						
COC		(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(C)	(D)	(D)*.001	(kg)	(mg/kg-bw/day)					
Inorganics	Iron		256	0	0.028	0.00	7.17	1	0.00	4400.00	0.42	1848	1848.00	1.85	0.01	4.95	0.0037			
	Lead		256	0	0.028	120.00	7.17	1	860.16	0.00	0.42	0	860.16	0.86	0.01	4.95	0.0017			
	Zinc		256	0	0.028	150.00	7.17	1	1075.20	0.00	0.42	0	1075.20	1.08	0.01	4.95	0.0022			
Organics	DRPH		256	0	0.028	730.00	7.17	1	5232.64	0.00	0.42	0	5232.64	5.23	0.01	4.95	0.0106			
	GRPH		256	0	0.028	95.00	7.17	1	680.96	280.00	0.42	109.2	790.16	0.79	0.01	4.95	0.0016			
	Toluene		256	0	0.028	0.11	7.17	1	0.79	0.00	0.42	0	0.79	0.00	0.01	4.95	0.0000			
	Xylenes (total)		256	0	0.028	1.20	7.17	1	8.60	0.00	0.42	0	8.60	0.01	0.01	4.95	0.0000			
	Aroclor 1254		256	0	0.028	4.80	7.17	1	34.41	0.00	0.42	0	34.41	0.03	0.01	4.95	0.0001			

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

Estimated Exposure = $\{[(CF*FI) + (CS*SI*ROA) + (CW*WI)] * .001\} * IS / BW$														
INSTALLATION	COC Conc	Food Intake Rate (FI)	Soil/Sed Intake % (SI)	COC Conc / Sed (CS)	Soil/Sed Ingestion Rate (SI)	Relative Availability (ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI) (A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW-EE)	
SPECIES	Food Items (CF)*	(FI)	(SI)	(CS)	(SI)	(ROA)	(CS*SI*ROA)	(WI)	(CW*WI)	(A+B+C)	(IS)	(BW)	(D*IS/BW-EE)	
brown lemming	(mg/kg)	(g/day)	(%)	(mg/kg)	(g/day)	(unitless)	(B)	(L/day)	(C)	(D)	(D)*.001 (unitless)	(kg)	(mg/kg-bw/day)	
COC														
Inorganics														
Iron	0.00	45	0.00	0.00	1.22	1	0.00	0.007	30.8	30.80	0.03	0.5	0.055	0.2800
Lead	2.70	45	121.50	120.00	1.22	1	145.80	0.007	0	267.30	0.27	0.5	0.055	2.4300
Zinc	112.50	45	5062.50	150.00	1.22	1	182.25	0.007	0	5244.75	5.24	0.5	0.055	47.6795
Organics														
DRPH	12.21	45	549.67	0.027	730.00	1	886.95	0.007	0	1436.62	1.44	0.5	0.055	13.0602
GRPH	0.00	45	0.00	0.027	95.00	1	115.43	0.007	1.82	117.25	0.12	0.5	0.055	1.0659
Toluene	0.06	45	2.67	0.027	0.11	1	0.13	0.007	0	2.81	0.00	0.5	0.055	0.0255
Xylenes (total)	0.58	45	26.20	0.027	1.20	1	1.46	0.007	0	27.66	0.03	0.5	0.055	0.2514
Aroclor 1254	0.01	45	0.41	0.027	4.80	1	5.83	0.007	0	6.24	0.01	0.5	0.055	0.0567

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

$$\text{Estimated Exposure} = \{[(CF*FI) + (CS*SI*ROA) + (CW*WI)] * .001\} * IS / BW$$

Estimated Exposure = (((CF*FI) + (CS*SI*ROA) + (CW*WI)) * .001)* IS) / BW																	
INSTALLATION																	
Point Barrow																	
SPECIES																	
caribou																	
COC																	
		COC Conc.	Food Intake Rate (FI)	Soil/Sed. Intake % (SI%)	Soil/Sed. Conc. (CS)	Soil/Sed. Rate (SI)	Relative Oral Availability (ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(C)	(D)	(D)*.001	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW=EE)		
		(mg/kg)	(g/day)	(A)	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(g)	(D)	(unitless)	(kg)	(mg/kg-bw/day)		
Inorganics	Iron	0.00	2400	0.00	0.02	0.00	48	1	0.00	4400.00	6.0	26400	26400.00	26.40	0.01	95.5	0.0028
	Lead	0.05	2400	129.60	0.02	120.00	48	1	5760.00	0.00	6.0	0	5889.60	5.89	0.01	95.5	0.0006
	Zinc	2.25	2400	5400.00	0.02	150.00	48	1	7200.00	0.00	6.0	0	12600.00	12.60	0.01	95.5	0.0013
Organics	DRPH	0.24	2400	586.32	0.02	730.00	48	1	35040.00	0.00	6.0	0	35626.32	35.63	0.01	95.5	0.0037
	GRPH	0.00	2400	0.00	0.02	95.00	48	1	4560.00	260.00	6.0	1560	6120.00	6.12	0.01	95.5	0.0006
	Toluene	0.00	2400	2.85	0.02	0.11	48	1	5.28	0.00	6.0	0	8.13	0.01	0.01	95.5	0.0000
	Xylenes (total)	0.01	2400	27.95	0.02	1.20	48	1	57.60	0.00	6.0	0	85.55	0.09	0.01	95.5	0.0000
	Aroclor 1254	0.00	2400	0.43	0.02	4.80	48	1	230.40	0.00	6.0	0	230.83	0.23	0.01	95.5	0.0000

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

Estimated Exposure = $\frac{((CF*FI) + (CS*SI*ROA) + (CW*WI)) * 0.01 * IS}{BW}$																																	
INSTALLATION Point Lonely SPECIES Lapland longspur	COC		Food		Soil/Sed.		COC		Soil/Sed.		Relative		COC		Water		Percent																
	Conc.		Intake		Intake		Conc.		Conc.		Oral		Conc.		Intake		Ingested																
	Food Items		Rate		%		Sol / Sed.		Rate		Availability		Water		Rate		at Site																
	(CF)*		(FI)		(SI%)		(CS)		(SI)		(ROA)		(CW)		(WI)		(IS)																
	(mg/kg)		(g/day)		(A)		% of FI		(mg/kg)		(unitless)		(B)		(ug/L)		(L/day)		(D)		(C)		(A+B+C)		0.0010		(D)* 0.01		(unitless)		(kg)		(mg/kg-bw/day)
Inorganics	Iron	0.00	6.6	0.00	0.02	0.00	0.13	1	0.00	4400.00	0.005	22.00	22.00	0.02	0.5	0.027	0.4074																
	Lead	1.08	6.6	7.13	0.02	120.00	0.13	1	15.84	0.00	0.005	22.97	0.00	0.02	0.5	0.027	0.4253																
	Zinc	45.00	6.6	297.00	0.02	150.00	0.13	1	19.80	0.00	0.005	316.80	0.00	0.32	0.5	0.027	5.8667																
Organics	DRPH	4.89	6.6	32.25	0.02	730.00	0.13	1	96.36	0.00	0.005	128.61	0.00	0.13	0.5	0.027	2.3816																
	GRPH	0.00	6.6	0.00	0.02	95.00	0.13	1	12.54	260.00	0.005	13.84	1.30	0.01	0.5	0.027	0.2563																
	Toluene	0.02	6.6	0.16	0.02	0.11	0.13	1	0.01	0.00	0.005	0.17	0.00	0.00	0.5	0.027	0.0032																
	Xylenes (total)	0.23	6.6	1.54	0.02	1.20	0.13	1	0.16	0.00	0.005	1.70	0.00	0.00	0.5	0.027	0.0314																
	Aroclor 1254	0.00	6.6	0.02	0.02	4.80	0.13	1	0.63	0.00	0.005	0.66	0.00	0.00	0.5	0.027	0.0122																

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

Estimated Exposure = $(\frac{[(CF*FI) + (CS*SI*ROA) + (CW*WI)] * .001}{IS}) / BW$													
INSTALLATION	COC Conc. Food Intake Rate (FI)	Soil/Sed. Intake % (SI%)	COC Conc. Soil / Sed. (CS)	Soil/Sed. Ingestion Rate (SI)	Relative Oral Availability (ROA)	COC Conc. Water (CW)	Water Intake Rate (WI)	(CW*WI) (A+B+C)	Conver. Units 0.0010	Percent Ingested at Site (IS)	Body Weight (BW)	ESTIMATED EXPOSURE (D*IS/BW-EE)	
SPECIES	Food Items (CF)*	(CF*FI)	(SI%)	(CS)	(SI)	(ROA)	(CW)	(WI)	(A+B+C)	(D)*.001	(IS)	(BW)	(D*IS/BW-EE)
glaucous gull	(mg/kg)	(g/day)	% of FI	(mg/kg)	(g/day)	(unitless)	(ug/L)	(L/day)	(D)	(D)*.001	(unitless)	(kg)	(mg/kg-bw/day)
COC													
Inorganics													
Iron	0.00	73.9	0.00	0.076	0.00	5.62	1	0.00	4400.00	0.08	352.00	352.00	0.0073
Lead	0.05	73.9	3.99	0.076	120.00	5.62	1	673.97	0.00	0.08	0.00	677.96	0.0140
Zinc	2.25	73.9	166.28	0.076	150.00	5.62	1	842.46	0.00	0.08	0.00	1008.74	0.0209
Organics													
DRPH	0.24	73.9	18.05	0.076	730.00	5.62	1	4099.97	0.00	0.08	0.00	4118.03	0.0852
GRPH	0.00	73.9	0.00	0.076	95.00	5.62	1	533.56	260.00	0.08	20.80	554.36	0.0115
Toluene	0.00	73.9	0.09	0.076	0.11	5.62	1	0.62	0.00	0.08	0.00	0.71	0.0000
Xylenes (total)	0.01	73.9	0.86	0.076	1.20	5.62	1	6.74	0.00	0.08	0.00	7.60	0.0002
Aroclor 1254	0.00	73.9	0.01	0.076	4.80	5.62	1	26.96	0.00	0.08	0.00	26.97	0.0006

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

Estimated Exposure = $\{[(CF*FI) + (CS*SI*ROA) + (CW*WI)] * .001\} * IS\} / BW$																	
INSTALLATION Point Lonely SPECIES brant	COC	Food	Soil/Sed.	COC	Soil/Sed.	Relative	COC	Water	Percent	ESTIMATED EXPOSURE (D*IS/BW=EE)							
	Conc.	Intake	Conc.	Intake	Oral	Conc.	Intake	Ingested									
	Food Items	Rate	%	Rate	Availability	Water	Rate	at Site									
	(CF)*	(FI)	(SI%)	(CS)	(SI)	(ROA)	(CW)	(WI)	(IS)								
	(mg/kg)	(g/day)	(A)	% of FI	(mg/kg)	(g/day)	(unitless)	(B)	(ug/L)		(C)	(D)	(D)* .001	(unitless)	(kg)	(mg/kg-bw/day)	
Inorganics	Iron	0.00	69.2	0.00	0.082	0.00	5.67	1	0.00	4400.00	0.07	308	308.00	0.31	0.2	1.31	0.0470
	Lead	0.16	69.2	11.21	0.082	120.00	5.67	1	680.93	0.00	0.07	0	692.14	0.69	0.2	1.31	0.1057
	Zinc	5.75	69.2	467.10	0.082	150.00	5.67	1	851.16	0.00	0.07	0	1318.26	1.32	0.2	1.31	0.2013
Organics	DRPH	0.73	69.2	50.72	0.082	730.00	5.67	1	4142.31	0.00	0.07	0	4193.03	4.19	0.2	1.31	0.6402
	GRPH	0.00	69.2	0.00	0.082	95.00	5.67	1	539.07	260.00	0.07	18.2	557.27	0.56	0.2	1.31	0.0851
	Toluene	0.00	69.2	0.25	0.082	0.11	5.67	1	0.62	0.00	0.07	0	0.87	0.00	0.2	1.31	0.0001
	Xylenes (total)	0.03	69.2	2.42	0.082	1.20	5.67	1	6.81	0.00	0.07	0	9.23	0.01	0.2	1.31	0.0014
	Acroclor 1254	0.00	69.2	0.04	0.082	4.80	5.67	1	27.24	0.00	0.07	0	27.27	0.03	0.2	1.31	0.0042

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

$$\text{Estimated Exposure} = ([\text{CF} \cdot \text{FI}] + (\text{CS} \cdot \text{SI} \cdot \text{ROA}) + (\text{CW} \cdot \text{WI})] \cdot 0.001) \cdot \text{IS} / \text{BW}$$

INSTALLATION																		
Point Lonely																		
SPECIES																		
pectoral sandpiper																		
COC																		
Inorganics																		
Iron		0.00	11.1	0.00	0.181	0.00	2.01	1	0.00	4400.00	0.01	44	44.00	0.04	0.87	0.08	0.4785	
Lead		5.40	11.1	59.94	0.181	120.00	2.01	1	241.09	0.00	0.01	0	301.03	0.30	0.87	0.08	3.2737	
Zinc		225.00	11.1	2497.50	0.181	150.00	2.01	1	301.37	0.00	0.01	0	2798.87	2.80	0.87	0.08	30.4377	
Organics																		
DRPH		24.43	11.1	271.17	0.181	730.00	2.01	1	1466.64	0.00	0.01	0	1737.82	1.74	0.87	0.08	18.8987	
GRPH		0.00	11.1	0.00	0.181	95.00	2.01	1	190.86	260.00	0.01	2.6	193.46	0.19	0.87	0.08	2.1039	
Toluene		0.12	11.1	1.32	0.181	0.11	2.01	1	0.22	0.00	0.01	0	1.54	0.00	0.87	0.08	0.0167	
Xylenes (total)		1.16	11.1	12.93	0.181	1.20	2.01	1	2.41	0.00	0.01	0	15.34	0.02	0.87	0.08	0.1668	
Aroclor 1254		0.02	11.1	0.20	0.181	4.80	2.01	1	9.64	0.00	0.01	0	9.84	0.01	0.87	0.08	0.1071	

ESTIMATED EXPOSURE EQUATION FOR BIRDS AND MAMMALS at POINT BARROW

Estimated Exposure = $\{[(CF*FI) + (CS*SI*ROA) + (CW*WI)] * 0.01\} * IS\} / BW$																
INSTALLATION Point Lonely SPECIES spectacled eider	COC	Food	Soil/Sed.	COC	Soil/Sed.	Relative	COC	Water	Conver.	Percent	Body	ESTIMATED				
	Conc.	Intake	Intake	Conc.	Intake	Oral	Conc.	Intake	Units	Ingested	Weight	EXPOSURE				
	Food Items	Rate	%	Soil / Sed.	Rate	Availability	Water	Rate	0.0010	at Site	(BW)	(D*IS/BW=EE)				
	(CF)*	(FI)	(CF*FI)	(SI%)	(SI)	(ROA)	(CS*SI*ROA)	(WI)	(A+B+C)	(IS)						
	(mg/kg)	(g/day)	(A)	% of FI	(g/day)	(unitless)	(B)	(ug/L)	(L/day)	(C)	(D)	(D)* 0.01	(mg/kg-bw/day)			
Inorganics	Iron	0.00	71.6	0.0000	0.082	6	1	0.00	4400.00	0.07	308	308.00	0.31	0.01	1.375	0.0022
	Lead	1.35	71.6	96.6600	0.082	6	1	704.54	0.00	0.07	0	801.20	0.80	0.01	1.375	0.0058
	Zinc	56.25	71.6	4027.5000	0.082	6	1	880.68	0.00	0.07	0	4908.18	4.91	0.01	1.375	0.0357
Organics	DRPH	6.11	71.6	437.2964	0.082	6	1	4285.98	0.00	0.07	0	4723.27	4.72	0.01	1.375	0.0344
	GRPH	0.00	71.6	0.0000	0.082	6	1	557.76	260.00	0.07	18.2	575.96	0.58	0.01	1.375	0.0042
	Toluene	0.03	71.6	2.1253	0.082	6	1	0.65	0.00	0.07	0	2.77	0.00	0.01	1.375	0.0000
	Xylenes (total)	0.29	71.6	20.8437	0.082	6	1	7.05	0.00	0.07	0	27.89	0.03	0.01	1.375	0.0002
	Aroclor 1254	0.00	71.6	0.3242	0.082	6	1	28.18	0.00	0.07	0	28.51	0.03	0.01	1.375	0.0002

APPENDIX F
SCALING FACTOR CALCULATIONS

SCALING FACTOR CALCULATIONS for POINT BARROW ERA

Scaling factor (SF) = (representative species average body weight/ test species average body weight)^{1/3}
 based on the mass to surface area ratios of the test species and the representative species
 (Mantel and Schneiderman 1975)

Representative Species	Average Body Weight (kg)	Test Species	Average Body Weight (kg)	Scaling Factor (SF)
brown lemming	0.055	mouse	0.025	1.30
	0.055	rat	0.25	0.60
arctic fox	4.95	mouse	0.025	5.82
	4.95	rat	0.25	2.70
	4.95	mink	1.0	1.70
caribou	95.5	sheep	60	1.17
	95.5	cattle	500	0.58
	95.5	rat	0.25	7.24
	95.5	mouse	0.025	15.59
Lapland longspur	0.027	chicken	0.8	0.32
	0.027	mallard	1.08	0.29
	0.027	Japanese quail	0.10	0.65
	0.027	ringed dove	0.155	0.56
	0.027	ring-necked pheasant	1.14	0.29
brant	1.305	chicken	0.8	1.18
	1.305	mallard	1.08	1.07
	1.305	Japanese quail	0.10	2.35
	1.305	ringed dove	0.155	2.03
	1.305	ring-necked pheasant	1.14	1.05
glaucous gull	1.445	chicken	0.8	1.22
	1.445	mallard	1.08	1.10
	1.445	Japanese quail	0.10	2.43
	1.445	ringed dove	0.155	2.10
	1.445	ring-necked pheasant	1.14	1.08
pectoral sandpiper	0.079	chicken	0.8	0.46
	0.079	mallard	1.08	0.42
	0.079	Japanese quail	0.10	0.92
	0.079	ringed dove	0.155	0.80
	0.079	ring-necked pheasant	1.14	0.41
spectacled eider	1.375	chicken	0.8	1.20
	1.375	mallard	1.08	1.08
	1.375	Japanese quail	0.10	2.39
	1.375	ringed dove	0.155	2.07
	1.375	ring-necked pheasant	1.14	1.06

APPENDIX G
RI ANALYTICAL DATA

G-1.	ALL (SUMMARY OF RI SAMPLING AND ANALYSIS)	G-1
G-2.	BACKGROUND (BKGD)	G-3
G-3.	DIESEL FUEL SPILL (SS01)	G-11
G-4.	GARAGE (SS02)	G-18
G-5.	AIR TERMINAL AREA (SS03)	G-23

TABLE G-1. SUMMARY OF SAMPLING AND ANALYSES CONDUCTED FOR I

ANALYSES	HVOC*	BTEX*	VOC 8260	SVOC	Metals ^b	TPH-Diesel ^b Range 3510/3550	TPH - Gasoline ^b Range
ANALYTICAL METHOD	SW8010M	SW8020	SW8260	SW8270	SW3050 (Soil) 3005 (Water)/6010	Diesel 8100 M	Gas 5030/8015M
POINT BARROW (POW-M)							
Background (BKGD)	5 Soil 2 Water	5 Soil 2 Water	1 Soil 2 Water	5 Soil 2 Water	5 Soil 2 Water (Total) 2 Water (Dissolved)	5 Soil 2 Water	5 Soil 2 Water
Diesel Fuel Spill (SS01)	NA	12 Soil 7 Water	2 Soil 1 Water	2 Soil	NA	20 Soil 7 Water	11 Soil 7 Water
Garage (SS02)	5 Soil	5 Soil	2 Soil	1 Soil	1 Soil	6 Soil	6 Soil
Air Terminal Area (SS03)	12 Soil 7 Water	14 Soil 7 Water	3 Soil 2 Water	2 Soil 2 Water	2 Soil 2 Water (Total) 2 Water (Dissolved)	19 Soil 7 Water	18 Soil 7 Water
Total Field Analyses	22 Soil 9 Water	36 Soil 16 Water	8 Soil 5 Water	10 Soil 4 Water	8 Soil 4 Water (Total) 4 Water (Dissolved)	50 Soil 16 Water	40 Soil 16 Water
QA/QC SAMPLES							
Trip Blanks	2 Water	2 Water	4 Water	NA	NA	NA	2 Water
Equipment Blanks	1 Water	1 Water	2 Water	NA	1 Water (Total)	1 Water	2 Water
Ambient Condition Blanks	NA	NA	1 Water	NA	NA	NA	NA
Field Replicates	3 Soil	4 Soil	1 Soil	1 Soil	1 Soil	5 Soil	5 Soil
Field Duplicates	1 Water	2 Water	1 Water	1 Water	1 Water (Total) 1 Water (Dissolved)	2 Water	2 Water
Investigation Derived Wastes (IDW)	NA	NA	NA	NA	NA	NA	NA
Total Site Analyses	25 Soil 13 Water	40 Soil 21 Water	9 Soil 13 Water	11 Soil 5 Water	9 Soil 6 Water (Total) 5 Water (Dissolved)	55 Soil 19 Water	45 Soil 22 Water

NA Not analyzed.

* These analyses were completed on a quick turnaround basis.

^a The number of soil sample includes sediment samples collected from surface water features.

^b Some of these analysis were completed on a 24-hour turnaround at a temporary fixed laboratory at Barrow, Alaska.

D FOR POINT BARROW REMEDIAL INVESTIGATIONS*

soline ^b ge	TPH Residual Range*	PCB*	Pesticides*	TDS	TSS	TOC	TCLP	TOTAL SAMPLES
8015M	Diesel 8100M	SW8080/8080M	SW8080/8080M	E160.1	E160.2	SW9060	SW1311	
oil ter	5 Soil 2 Water	5 Soil 2 Water	5 Soil 2 Water	2 Water	2 Water	2 Soil 2 Water	NA	5 Soil 2 Water
oil ter	11 Soil 7 Water	NA	1 Soil	1 Water	1 Water	1 Soil 1 Water	NA	20 Soil 7 Water
oil	5 Soil	5 Soil	2 Soil	NA	NA	NA	NA	6 Soil
oil ter	13 Soil 7 Water	7 Soil 7 Water	1 Soil	2 Water	2 Water	2 Soil 2 Water	NA	19 Soil 7 Water
oil water	34 Soil 16 Water	17 Soil 9 Water	9 Soil 2 Water	5 Water	5 Water	5 Soil 5 Water		50 Soil 16 Water
ter	NA	NA	NA	NA	NA	NA	NA	4 Water
ter	1 Water	1 Water	1 Water	NA	NA	NA	NA	2 Water
A	NA	NA	NA	NA	NA	NA	NA	1 Water
oil	4 Soil	2 Soil	1 Soil	NA	NA	1 Soil	NA	5 Soil
water	2 Water	1 Water	NA	1 Water	1 Water	1 Water	NA	2 Water
A	NA	NA	NA	NA	NA	NA	1 Water	1 Water
oil water	38 Soil 19 Water	19 Soil 11 Water	10 Soil 3 Water	6 Water	6 Water	6 Soil 6 Water	1 Water	55 Soil 26 Water

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY

Installation: Point Barrow Site: Background (BKGD)		Matrix: Soil/Sediment Units: mg/kg		Environmental Samples						Field Blanks			Lab Blanks	
Parameters	Detect Limits	Quant. Limits	Action Levels	Bkgd. Range	S01	S02	S03	S04	SD01	AB01	EB01	TB01		
Laboratory Sample ID Numbers					820 4397-4	822 4397-5	824 4397-6	826 4397-7	818 4397-1	4395-2	1156/1158 4424-4	776 4395-1	#5-9193 4395 4424	#6-82893 4397
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
DRPH	6.5-18	65-180	500 ^a	<85.1 ^b - <180.1 ^b	<185.1 ^b	<170.1 ^b	<90.1 ^b	<85.1 ^b	<80.1 ^b	NA	<1,000 ^b	NA	<200	<50
GRPH	0.3-0.7	3-7	100	<3.1 ^b - <7.1 ^b	<7.1 ^b	<7.1 ^b	<4.1 ^b	<3.1 ^b	<3.1 ^b	NA	<100.1 ^b	<50.1 ^b	NA	NA
RRPH (Approx.)	13-36	130-360	2,000 ^a	<130 - <360	<360	<340	<180	<130	<150	NA	<2,000	NA	<2,000	<100
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 - <0.31	<0.31	<0.31	<0.19	<0.14	<0.15	<1 ^c	<1	<1	<1	NA
Benzene	0.003-0.007	0.03-0.07	0.5	<0.03 - <0.07	<0.07	<0.07	<0.04	<0.03	<0.03	<1 ^c	<1	<1	<1	NA
Toluene	0.003-0.007	0.03-0.07		<0.03 - <0.07	<0.07	<0.07	<0.04	<0.03	<0.03	<1 ^c	<1	<1	<1	NA
Ethylbenzene	0.003-0.007	0.03-0.07		<0.03 - <0.07	<0.07	<0.07	<0.04	<0.03	<0.03	<1 ^c	<1	<1	<1	NA
Xylenes (Total)	0.005-0.01	0.05-0.1		<0.05 - <0.1	<0.1	<0.1	<0.07	<0.05	<0.06	<2 ^c	<2	<2	<2	NA
HVOC 8010	0.003-0.007	0.03-0.07		<0.03 - <0.07	<0.07	<0.07	<0.04	<0.03	<0.03	NA	<1	<1	NA	NA
VOC 8260	0.020	0.050		<0.050J	NA	NA	NA	NA	<0.050J	<1	<1	<1	<1	<1
SVOC 8270	0.200	3.80-40.0		<3.80 - <40.0	<40.0 ^d	<18.0 ^d	<3.95 ^d	<5.9 ^d	<3.80 ^d	NA	NA	NA	NA	<0.200
Pesticides	0.001-0.05	0.01-0.5		<0.01 - <1.81	<0.41 - <1.81	<0.31 - <1.71	<0.21 - <0.91	<0.01 - <0.5	<0.01 - <0.51	NA	<0.21 - <25R	NA	NA	NA
PCBs	0.01-0.04	0.1-0.4	10	<0.1 - <0.4J	<0.4J	<0.3J	<0.2J	<0.1	<0.1	NA	<2	NA	NA	<0.1
TOC				84,200-297,000	297,000	NA	NA	NA	84,200	NA	NA	NA	NA	NA

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

R Result has been rejected.

a The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

c BTEX determined by 8260 method analysis.

d The laboratory reported that the high detection limit on SVOC 8270 was due to the discoloration of the extract.

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Background (BKGD)		Matrix: Soil/Sediment Units: mg/kg		METALS ANALYSES									
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Bkgd. Range	Environmental Samples					Field Blank		Lab Blanks
						S01	S02	S03	S04	SD01	EB01		
Laboratory Sample ID Numbers						4397-4	4397-5	4397-6	4397-7	4397-1	4424-4	4424 4397	
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	
Aluminum	0.35	2		1,500-23,000	6,300-18,000	6,300	18,000	15,000	14,000	11,000	<100	<100	
Antimony	N/A	69-230		<7.8-<230	<69-<230	<230	<170	<75	<69	<120	<100	<100	
Arsenic	0.11	6.9-23		<4.9-7.0	<6.9-<23	<23	<17	<7.5	<6.9	<12	<100	<100	
Barium	0.024	1		27-390	110-230	110	230	220	150	180	<50	<50	
Beryllium	N/A	3.4-11		<2.6-6.4	<3.4-<11	<11	<8.5	<3.8	<3.4	<5.8	<50	<50	
Cadmium	0.33	3.4-11		<3.0-<27	<3.4-<11	<11	<8.5	<3.8	<3.4	<5.8	<50	<50	
Calcium	0.69	4		360-59,000	1,700-5,700	2,800	3,100	2,700	1,700	5,700	220	<200	
Chromium	0.066	1-11		<4.3-47	<11-30	<11	30	24	24	19	<50	<50	
Cobalt	N/A	6.9-23		<5.1-12	<6.9-<23	<23	<17	<7.5	<6.9	<12	<50	<100	
Copper	0.045	1		<2.7-45	13-20	13	17	20	18	17	<50	<50	
Iron	0.50	2		5,400-35,000	19,000-22,000	21,000	22,000	21,000	19,000	22,000	<100	<100	
Lead	0.13	2-23		<5.1-22	8.7-<23	<23	<17	9.7	8.7	<12	<100	<100	
Magnesium	0.96	4		360-7,400	2,000-4,500	2,000	4,500	3,500	3,200	3,600	<200	<200	
Manganese	0.025	1		25-290	49-240	49	86	90	74	240	<50	<50	
Molybdenum	N/A	3.4-11		<2.5-<11	<3.4-<11	<11	<8.5	<3.8	<3.4	<5.8	<50	<50	
Nickel	0.11	1		<4.2-46	23-25	23	25	23	23	24	<50	<50	
Potassium	23	100-1100		<300-2,200	<1,100-2,200	<1,100	2,200	1,600	2,000	2,000	<5,000	<5,000	
Selenium	1.2	23-170		<7.8-170	<23-<170	<23	<170	<75	<69	<120	<100	<100	
Silver	0.53	34-110		<3-<110	<34-<110	<110J	<85	<38	<34	<58J	<50	<50	
Sodium	0.55	5		<160-680	190-640	640	390	220	190	310	<250	<250	

☐ CT&E Data.
☐ N/A Not available.
☐ J Result is an estimate.

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Background (BKGD)		Matrix: Soil/Sediment Units: mg/kg				METALS ANALYSES						Field Blank		Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW/ Line Installations	Bkgd. Range	Environmental Samples						EB01		
Laboratory Sample ID Numbers						S01	S02	S03	S04	SD01				4424 4397
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	4397-4	4397-5	4397-6	4397-7	4397-1				µg/L
Thallium	0.001	0.32-1.2		<0.2-<0.82	<0.32-<1.2	<1.2	<0.82	<0.39	<0.32	<0.55				<5
Vanadium	0.036	1		6.3-59	18-48	18	48	41	44	39				<50
Zinc	0.16	1		9.2-95	49-61	61	59	49	51	59				<50

☐ CT&E Data.

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Background (BKGD)		Matrix: Surface Water Units: µg/L		Environmental Samples		Field Blanks			Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range	SW01	SW02	AB01	EB01	TB01
Laboratory Sample ID Numbers					778/780 4395-3	784/786 4394-1 4395-6	4395-2	1156-1158 4424-4	776 4395-1
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
DRPH	100	1,000		<1,000 ^b	<1,000 ^b	<1,000 ^b	NA	<1,000 ^b	NA
GRPH	5	50		<50J ^b	<50J ^b	<50J ^b	NA	<100J ^b	<50J ^b
RRPH (Approx.)	200	2,000		<2,000	<2,000	<2,000	NA	<2,000	NA
BTEX (8020/8020 Mod.)									
Benzene	0.1	1	5	<1	<1	<1	<1 ^c	<1	<1
Toluene	0.1	1	1,000	<1	<1	<1	<1 ^c	<1	<1
Ethylbenzene	0.1	1	700	<1	<1	<1	<1 ^c	<1	<1
Xylenes (Total)	0.2	2	10,000	<2	<2	<2	<2 ^c	<2	<2
HVOC 8010	0.1	1		<1	<1	<1	NA	<1	<1
VOC 8260									
1,2-Dichloroethane	1	1	5	<1-1.2	1.2	<1	<1	<1	<1
SVOC 8270	10	10-25		<10-25	<10J	<25	NA	NA	NA
Pesticides	0.02-5	0.2-50		<0.2J-50R	<0.2J-50R	<0.2J-50R	NA	<0.2J-25R	NA
PCBs	0.2	2	0.5	<2	<2	<2	NA	<2	NA

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

R Result has been rejected.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

c BTEX determined by 8260 method analysis.

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Background (BKGD)		Matrix: Surface Water Units: µg/L								Field Blanks			Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range	SW01	SW02	AB01	EB01	TB01				
Laboratory Sample ID Numbers					778/780 4395-3	784/786 4394-1 4395-6	4395-2	1156-1158 4424-4	776 4395-1				
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L				
TOC	5,000	5,000		16,700-22,500	16,700	22,500	NA	NA	NA				
TSS	100	200		5,000-6,000	5,000	6,000	NA	NA	NA				
TDS	10,000	10,000		166,000J-213,000	166,000J	213,000	NA	NA	NA				

☐ CT&E Data.
 NA Not analyzed.
 J Result is an estimate.

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Background (BKGD)			Matrix: Surface Water Units: µg/L		METALS ANALYSES: TOTAL (DISSOLVED)							
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Bkgd. Range	Environmental Samples			Field Blank		Lab Blanks	
						SW01	SW02			EB01		
Laboratory Sample ID Numbers												4424 4394 4395
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L							µg/L
Aluminum	17.4	100		<100-350 (<100-340)	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)			<100	<100 (<100)
Antimony	N/A	100	6	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)			<100	<100 (<100)
Arsenic	5.3	100	50	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)			<100	<100 (<100)
Barium	1.2	50	2,000	<50-93 (<50-91)	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)			<50	<50 (<50)
Beryllium	N/A	50	4	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)			<50	<50 (<50)
Cadmium	1.7	50	5	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)			<50	<50 (<50)
Calcium	34.5	200		4,500-88,000 (4,100-86,000)	8,000-13,000 (8,500-14,000)	8,000 (8,500)	13,000 (14,000)				220	<200 (<200)
Chromium	3.29	50	100	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)			<50	<50 (<50)
Cobalt	N/A	100		<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)			<50	<100 (<100)
Copper	2.3	50	1,300	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)			<50	<50 (<50)
Iron	25	100		180-2,800 (<100-1,600)	180-250 (150-360)	180 (150)	250 (360)				<100	<100 (<100)

☐ CT&E Data.
N/A Not available.

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

METALS ANALYSES: TOTAL (DISSOLVED)												
Installation: Point Barrow Site: Background (BKGD)			Matrix: Surface Water Units: µg/L		Bkgd. Range from 7 DEW Line Installations				Field Blank			Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range	SW01	SW02	Environmental Samples	EB01				
Laboratory Sample ID Numbers					4395-3	4394-1		4424-4		4424 4394 4395		
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L		
Lead	6.6	100	15	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)	<100	<100 (<100)	<100 (<100)		
Magnesium	47.8	200		2,900-53,000 (2,600-54,000)	10,000-14,000 (10,000-14,000)	10,000 (10,000)	14,000 (14,000)	<200	<200 (<200)	<200 (<200)		
Manganese	1.24	50		<50-510 (<50-120)	<50 (<50)	<50 (<50)	<50 (<50)	<50	<50 (<50)	<50 (<50)		
Molybdenum	N/A	50		<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50	<50 (<50)	<50 (<50)		
Nickel	5.5	50	100	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50	<50 (<50)	<50 (<50)		
Potassium	1,154	5,000		<5,000 (<5,000)	<5,000 (<5,000)	<5,000 (<5,000)	<5,000 (<5,000)	<5,000	<5,000 (<5,000)	<5,000 (<5,000)		
Selenium	62.4	100	50	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)	<100	<100 (<100)	<100 (<100)		
Silver	2.6	50	50	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50	<50 (<50)	<50 (<50)		
Sodium	27.7	250		8,400-410,000 (8,200-450,000)	39,000J-49,000 (39,000J-46,000)	39,000J (39,000J)	49,000 (46,000)	<250	<250 (<250)	<250 (<250)		
Thallium	0.57	5	2	<5 (<5)	<5 (<5)	<5 (<5)	<5 (<5)	<5	<5 (<5)	<5 (<5)		
Vanadium	1.8	50		<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)	<50	<50 (<50)	<50 (<50)		

☐ CT&E Data.
☐ N/A Not available.
☐ J Result is an estimate.

TABLE G-2. BACKGROUND ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Background (BKGD)		Matrix: Surface Water Units: µg/L		METALS ANALYSES: TOTAL (DISSOLVED)					Field Blank		Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Bkgd. Range	Environmental Samples					
						SW01	SW02		EB01		
Laboratory Sample ID Numbers						4395-3	4394-1		4424-4		4424 4394 4395
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L		µg/L		µg/L
Zinc	8.2	50		<50-160 (<50)	<50-73 (<50)	<50 (<50)	73 (<50)		<50		<50 (<50)

☐ CT&E Data.

TABLE G-3. DIESEL FUEL SPILL ANALYTICAL DATA SUMMARY

Installation: Point Barrow Site: Diesel Fuel Spill (SS01)		Matrix: Soil/Sediment Units: mg/kg		Environmental Samples						Field Blanks			Lab Blanks	
Parameters	Detect Limits	Quant Limits	Action Levels	Bkgd. Levels	S01-2	S02-1.5	S03-2	SD01	SD02	SD03	AB01	EB01	TB02	Lab Blanks
Laboratory Sample ID Numbers					1198 4424-8	1200	1202	1138 4424-7	1138	1140	4395-2	1156/1158 4424-4	1154 4424-5	#5-9193 4424 #5-83183 4424
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L	μg/L
DRPH	6-10	80-100	500 ^a	<150 ^b	510 ^b	<100 ^b	<100 ^b	<90 ^b	70 ^b	<60 ^b	NA	<1,000 ^b	NA	<200
GRPH	0.1	1	100	<3 ^b	210 ^b	<1 ^b	<1 ^b	123 ^b	15 ^b	<1 ^b	NA	<100 ^b	<100 ^b	NA
RRPH (Approx.)	12-20	120-200	2,000 ^a	<130-360	<120	<200	<160	<120	<120	<120	NA	<2,000	NA	<2,000
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14-0.31	19.35J	0.4	0.1JR	1.86J	3.90J	<0.10	<1 ^c	<1	<1	<0.02
Benzene	0.002-0.004	0.02-0.04	0.5	<0.03-0.07	0.15J	<0.04	<0.03	<0.02	0.17J	<0.02	<1 ^c	<1	<1	<0.02
Toluene	0.002-0.004	0.02-0.04		<0.03-0.07	1.5	0.4	0.1R	0.2	0.43	<0.02	<1 ^c	<1	<1	<0.02
Ethylbenzene	0.002-0.004	0.02-0.04		<0.03-0.07	3.7	<0.04	<0.03	0.8	1.2	<0.02	<1 ^c	<1	<1	<0.02-0.03
Xylenes (Total)	0.004-0.008	0.04-0.08		<0.05-0.1	14J	<0.08	<0.08	0.8J	2.1J	<0.04	<2 ^c	<2	<2	<0.04-0.04
VOC 8260				<0.050J	0.903	NA	NA	<0.250	NA	NA	<1	<1	<1	<0.020
1,2,4-Trimethylbenzene	0.020	0.250-0.350				NA	NA							
1,3,5-Trimethylbenzene	0.020	0.250-0.350			0.396	NA	NA	<0.250	NA	NA	<1	<1	<1	<0.020
SVOC 8270														
di-n-Butylphthalate	0.200	2.40-9.30	8,000	<3.80-40.0	20.1B	NA	NA	5.19B	NA	NA	NA	NA	NA	1.610
bis (2-Ethylhexyl) Phthalate	0.200	2.40-9.30	50	<3.80-40	<9.30	NA	NA	3.42B	NA	NA	NA	NA	NA	<0.200
Pesticides	0.001-0.05	0.01-0.5		<0.01J-1.8J	NA	NA	NA	<0.01J-0.5R	NA	NA	NA	<0.2J-0.25R	NA	NA

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

B The analyte was detected in the associated blank.

J Result is an estimate.

R Result has been rejected.

a The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

c BTEX determined by 8260 method analysis.

TABLE G-3. DIESEL FUEL SPILL ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Diesel Fuel Spill (SS01)		Matrix: Soil/Sediment Units: mg/kg													
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks	
					S01-2	S02-1.5	S03-2	SD01	SD02	SD03	AB01	EB01	TB02		
Laboratory Sample ID Numbers					1198 4424-8	1200	1202	1138 4424-7	1138	1140	4395-2	1150/1158 4424-4	1154 4424-5	#5-9183 4424 4395	#1&2-9293 #5-63183 4424
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L	mg/kg
TOC				84,200-287,000	53,800	NA	NA	NA	NA	NA	NA	NA	NA	<5,000	NA

☐ CT&E Data.
☐ NA
 Not analyzed.

TABLE G-3. DIESEL FUEL SPILL ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Diesel Fuel Spill (SS01)		Matrix: Sediment Units: mg/kg		Field Blanks							Lab Blanks	
Parameters	Detect Limits	Quant Limits	Action Levels	Bkgd. Levels	Environmental Samples							
					SD04	SD05 & SD09 (Replicates)	SD06	SD07	SD08	AB01	EB01	TB02
Laboratory Sample ID Numbers					1142	1144	1196	1192	1194	4395-2	1156/1158 4424-4	1154 4424-5
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L
DRPH	6	60	500 ^a	<85.0 ^b <180.0 ^b	<60 ^b	<60 ^b	<60 ^b	<60 ^b	<60 ^b	NA	<1,000 ^b	NA
GRPH	0.1	1	100	<3.0 ^b <7.0 ^b	14.0 ^b	25.0 ^b	<1.0 ^b	<1.0 ^b	<1.0 ^b	NA	<100.0 ^b	<100.0 ^b
RRPH (Approx.)	12	120	2,000 ^a	<130 <380	<120	<120	<120	<120	<120	NA	<2,000	NA
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 <0.31	4.24 ^c	<0.10	<0.10	<0.10	<0.10	<1 ^c	<1	<1
Benzene	0.002	0.02	0.5	<0.03 <0.07	<0.02	<0.02	<0.02	<0.02	<0.02	<1 ^c	<1	<1
Toluene	0.002	0.02		<0.03 <0.07	0.08	<0.02	<0.02	<0.02	<0.02	<1 ^c	<1	<1
Ethylbenzene	0.002	0.02		<0.03 <0.07	0.66	<0.02	<0.02	<0.02	<0.02	<1 ^c	<1	<1
Xylenes (Total)	0.004	0.04		<0.05 <0.1	3.5 ^c	<0.04	<0.04	<0.04	<0.04	<2 ^c	<2	<2

☐ CT&E Data.
☒ F&B Data.
☒ NA
 J Not analyzed.
 R Result is an estimate.
 a Result has been rejected.
 b The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.
 c DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.
 BTEX determined by 8260 method analysis.

TABLE G-3. DIESEL FUEL SPILL ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Diesel Fuel Spill (SS01)															Matrix: Soil Units: mg/kg				
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples							Field Blanks			Lab Blanks				
					2S04-2	2S05-1	2S06-2	2S07-1	2S08-2	2S09-1	AB01	2EB02	2TB03						
Laboratory Sample ID Numbers					4627-2	4627-3	4627-4	4627-5	4627-6	4627-7	4395-2	4627-23	4627-22	4627	4395	4627			
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L	μg/L	μg/L	mg/kg			
DRPH	4.00	4.00	500 ^a	<65J ^b <180J ^b	596 ^{de}	3,960 ^d	15.4 ^f	2,210 ^d	416 ^g	26.2 ^h	NA	NA	NA	NA	NA	<4.00			
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 <0.31	NA	NA	NA	1.06N	NA	NA									
Benzene	0.020	0.250	0.5	<0.03 <0.07	NA	NA	NA	<0.250	NA	NA	<1 ^c	<1 ^c	<1 ^c	<1	<1	<0.020			
Toluene	0.020	0.250		<0.03 <0.07	NA	NA	NA	0.082N	NA	NA	<1 ^c	<1 ^c	<1 ^c	<1	<1	<0.020			
Ethylbenzene	0.020	0.250		<0.03 <0.07	NA	NA	NA	0.208N	NA	NA	<1 ^c	<1 ^c	<1 ^c	<1	<1	<0.020			
Xylenes (Total)	0.040	0.500		<0.05 <0.1	NA	NA	NA	0.770N	NA	NA	<2 ^c	<2 ^c	<2 ^c	<2	<2	<0.020			

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification".

a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.

b DRPH concentrations reported for these samples are equivalent to diesel range organics (DRO) as defined by ADEC.

c BTEX determined by 8260 method analysis.

d The laboratory reported that sample concentration was determined using a secondary dilution.

e The laboratory reported that 102 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

f The laboratory reported that 12.3 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

g The laboratory reported that 53.0 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

h The laboratory reported that 15.6 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-3. DIESEL FUEL SPILL ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Diesel Fuel Spill (SS01)		Matrix: Soil Units: mg/kg		Environmental Samples				Field Blanks			Lab Blank
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	2S10-0.5	2S11-0.5	2S12	AB01	2EB02	2TB03	
Laboratory Sample ID Numbers					4627-8	4627-9	4627-10	4395-2	4627-23	4627-22	4627
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L	mg/kg
DRPH	4.00	4.00	500 ^a	<65 ^b <180 ^b	13.6 ^c	21.9 ^d	13.1 ^d	NA	NA	NA	<4.00

□ CT&E Data.

■ F&B Data.

■ Not analyzed.

Result is an estimate.

The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.

DRPH concentrations reported for these samples are equivalent to diesel range organics (DRO) as defined by ADEC.

The laboratory reported that 8.99 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.

□

■

NA

J

a

b

c

d

TABLE G-3. DIESEL FUEL SPILL ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Diesel Fuel Spill (SS01)				Matrix: Surface Water Units: µg/L				Environmental Samples								Field Blanks			Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	SW01	SW02 & SW08 (Duplicates)	SW03	SW04	SW05	SW06	SW07	AB01	EB01	TB02					
Laboratory Sample ID Numbers					1160/1182 4424-6	1164/1166	1209	1168/1170	1172/1174	1176/1178	1180/1182	4395-2	1156/1158 4424-4	1154 4424-5	4395 #5-9193 4424				
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L				
DRPH	100	1,000		<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	NA	<1,000 ^b	NA	<200				
GRPH	10	100		<50 ^b	1,690 ^b	<100 ^b	<100 ^b	<100 ^b	<100 ^b	<100 ^b	<100 ^b	NA	<100 ^b	<100 ^b	NA				
RRPH (Approx.)	200	2,000		<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	NA	<2,000	NA	<2,000				
BTEX (8020/8020 Mod.)																			
Benzene	0.1	1	5	<1	9	<1	<1	2	<1	<1	<1	<1 ^c	<1	<1	<1				
Toluene	0.1	1	1,000	<1	42J	<1	<1	2J	<1	<1	<1	<1 ^c	<1	<1	<1				
Ethylbenzene	0.1	1	700	<1	14J	<1	<1	6J	<1	<1	<1	<1 ^c	<1	<1	<1				
Xylenes (Total)	0.2	2	10,000	<2	380J	<2	<2	23J	<2	<2	<2	<2 ^c	<2	<2	<2				
VOC 8260																			
Benzene	1	1	5	<1	3.5	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				
sec-Butylbenzene	1	1		<1	1.5	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				
Ethylbenzene	1	1	700	<1	13	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				
Isopropyl- benzene	1	1		<1	4.8	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				
p-Isopropyl- toluene	1	1		<1	4.0	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				
Naphthalene	1	1		<1	58	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				
n-Propylbenzene	1	1		<1	4.1	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				
Toluene	1	1	1,000	<1	28	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1				

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

c BTEX determined by 8260 method analysis.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

TABLE G-3. DIESEL FUEL SPILL ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Diesel Fuel Spill (SS01)					Matrix: Surface Water Units: µg/L					Environmental Samples							Field Blanks			Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	SW01	SW02 & SW08 (Duplicates)	SW03	SW04	SW05	SW06	SW07	AB01	EB01	TB02						
Laboratory Sample ID Numbers					1160/1162 4424-6	1164/1166	1168/1170	1172/1174	1176/1178	1180/1182	1184/1208	4395-2	1156/1158 4424-4	1154 4424-5	4395 #5-9183 4424					
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L					
1,2,4-Trimethyl- benzene	1	1		<1	92	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1					
1,3,5-Trimethyl- benzene	1	1		<1	52	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1					
Xylenes (Total)	2	2	10,000	<2	312	NA	NA	NA	NA	NA	NA	<2	<2	<2	<2					
TOC	5,000	5,000		16,700- 22,500	43,600	NA	NA	NA	NA	NA	NA	NA	NA	NA	<5,000					
TSS	100	200		5,000-6,000	90,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	<200					
TDS	10,000	10,000		166,000- 213,000	586,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	<10,000					

☐ CT&E Data.
☐ NA Not analyzed.

TABLE G-4. GARAGE ANALYTICAL DATA SUMMARY

Installation: Point Barrow Site: Garage (SS02)		Matrix: Soil/Sediment Units: mg/kg										Field Blanks				Lab Blanks	
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples					SD01	AB01	EB01	TB02				
					S01-1.5	S02	S03-1	S04 & S05 (Replicates)									
Laboratory Sample ID Numbers					1148	1150 4424-8	1152	1204	1206	1146	4355-2	1156 1158 4424-4	1154 4424-5	#5-9193 #182-9293 4424 4424			
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/L	mg/L	mg/L	mg/L	mg/L	mg/kg
DRPH	20	200	500 ^a	<65 ^b <180 ^b	2300 ^b	<50 ^b	830 ^b	570 ^b	450 ^b	<200 ^b	NA	<1,000 ^b	NA	<200	<50		
GRPH	0.1	1	100	<3 ^b <7 ^b	113 ^b	<1 ^b	63 ^b	<1 ^b	<1 ^b	<1 ^b	NA	<100 ^b	<100 ^b	NA	<1		
RRPH (Approx.)	10-40	100-400	2,000 ^c	<130 <360	<100	240	290	710	880	<400	NA	<2,000	NA	<2,000	<100		
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 <0.31	8.6J	<0.10	3.34J	<0.10	<0.10	<0.44							
Benzene	0.002-0.008	0.02-0.08	0.5	<0.03 <0.07	<0.02	<0.02	<0.02	<0.02	<0.02	<0.08	<1 ^c	<1	<1	<1	<0.02		
Toluene	0.002-0.008	0.02-0.08		<0.03 <0.07	1.3	<0.02	0.04	<0.02	<0.02	<0.08	<1 ^c	<1	<1	<1	<0.02		
Ethylbenzene	0.002-0.008	0.02-0.08		<0.03 <0.07	0.4	<0.02	0.9	<0.02	<0.02	<0.08	<1 ^c	<1	<1	<1	<0.02 <0.03		
Xylenes (Total)	0.004-0.02	0.04-0.2		<0.05 <0.1	6.9J	<0.04	2.4J	<0.04	<0.04	<0.12	<2 ^c	<2	<2	<2	<0.04 <0.09		
HVOC 8010																	
Tetrachloroethene	0.002-0.008	0.02-0.08		<0.03 <0.07	<0.02	<0.02	0.3	<0.02	<0.02	<0.08	NA	<1	<1	<1	<0.02		
Trichloroethene	0.002-0.008	0.02-0.08		<0.03 <0.07	<0.02	<0.02	0.6	<0.02	<0.02	<0.08	NA	<1	<1	<1	<0.02		
VOC 8260																	
Styrene	0.020	0.020		<0.050J	NA	0.187	NA	NA	NA	NA	<1	NA	<1	<1	<0.020		
SVOC 8270	0.200	2.10		<3.80 <40	NA	<2.10	NA	NA	NA	NA	NA	NA	NA	NA	<0.200		
PCBs																	
Aroclor 1254	0.01	0.1	10	<0.4J	<0.1	14	3.7J	11.0J	10.4J	<0.1	NA	<2	NA	NA	<0.1		

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

R Result has been rejected.

a The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

c BTEX determined by 8260 method analysis.

d The laboratory reported that the sample contained high lube oil or cutting oil.

TABLE G-4. GARAGE ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Garage (SS02)														
Matrix: Soil/Sediment Units: mg/kg														
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks
					S01-1.5	S02	S03-1	S04 & S05 (Replicates)		SD01	AB01	EB01	TB02	
Laboratory Sample ID Numbers					1148	1150 4424-8	1152	1204	1206	1146	4395-2	1156 1158 4424-4	1154 4424-5	#5-9193 4424 4395 #5-83193 #1&2-9293 4424
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L	mg/kg
Pesticides	0.001-0.05	0.01-0.5		<0.01 μg/L < 1.8 μg/L	<0.01 < 0.5R	NA	NA	NA	NA	<0.01 < 0.5R	NA	<0.2 μg/L < 25R	NA	NA

☐ CT&E Data.
☐ NA Not analyzed.
☐ J Result is an estimate.
☐ R Result has been rejected.

TABLE G-4. GARAGE ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Garage (SS02)		Matrix: Soil Units: mg/kg									
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Sample		Field Blanks			Lab Blanks	
					2S06-2		AB01	2EB03	2TB03		
Laboratory Sample ID Numbers					4627-1		4395-2	4827-23	4627-22	4627 4395	4627
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		μg/L	μg/L	μg/L	μg/L	mg/kg
DRPH	4.00	4.00	500 ^a	<65. ^b <180. ^a	292		NA	NA	NA	NA	<4.00
GRPH	0.400	0.400	100	<3. ^b <7. ^a	2.05		NA	<20	NA	<20	<0.400
VOC 8260	0.020	0.020		<0.050J	<0.020J		<1	<1	<1	<1	<1

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

a The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

TABLE G-4. GARAGE ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Garage (SS02)		Matrix: Soil Units: mg/kg		METALS ANALYSES										Field Blank		Lab Blank
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	S02									EB01		
Laboratory Sample ID Numbers					4424-9									4424-4		4424
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg									µg/L		µg/L
Aluminum	0.35	2		1,500-23,000	1,000									<100		<100
Antimony	N/A	51		<7.8-<230	<51									<100		<100
Arsenic	0.11	51		<4.9-7.0	<51									<100		<100
Barium	0.024	1		27-390	110									<50		<50
Beryllium	N/A	2.6		<2.6-6.4	<2.6									<50		<50
Cadmium	0.33	1		<3.0-<27	3.9									<50		<50
Calcium	0.69	4		360-59,000	1,200									220		<200
Chromium	0.066	1		<4.3-47	31									<50		<50
Cobalt	N/A	5.1		<5.1-12	<5.1									<50		<100
Copper	0.045	1		<2.7-45	20									<50		<50
Iron	0.50	2		5,400-35,000	7,600									<100		<100
Lead	0.13	2		<5.1-22	150									<100		<100
Magnesium	0.96	4		360-7,400	650									<200		<200
Manganese	0.025	1		25-290	45									<50		<50
Molybdenum	N/A	2.6		<2.5-<11	<2.6									<50		<50
Nickel	0.11	1		4.2-46	5.2									<50		<50
Potassium	23	100		<300-2,200	350									<5,000		<5,000
Selenium	1.2	51		<7.8-<170	<51									<100		<100

☐ CT&E Data.
N/A Not available.

TABLE G-4. GARAGE ANALYTICAL DATA SUMMARY (CONTINUED)

METALS ANALYSES									
Installation: Point Barrow Site: Garage (SS02)		Matrix: Soil Units: mg/kg		Environmental Sample					Lab Blank
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	S02			Field Blank	
Laboratory Sample ID Numbers					4424-9			4424-4	4424
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			µg/L	µg/L
Silver	0.53	2.6		<3-<110	<2.6			<50	<50
Sodium	0.55	5		<160-680	100			<250	<250
Thallium	0.011	0.24		<0.2-<0.82	<0.24			<5	<5
Vanadium	0.036	1		6.3-59	8.1			<50	<50
Zinc	0.16	1		9.2-95	270			<50	<50

☐ CT&E Data.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY

Installation: Point Barrow Site: Air Terminal Area (SS03)				Matrix: Soil Units: mg/kg		Environmental Samples								Field Blanks			Lab Blanks	
Parameters	Detect Limits	Quant. Limits	Action Levels	Bkgd. Levels	S01-3.5	S02-3	S03-2	S04-4	S05-4	S06-4 & S07-4 (Replicates)	AB01	EB01	TB02					
Laboratory Sample ID Numbers					1122	1124	1126	1128 4424-1	1130	1132	1134	1156/1158 4424-4	1154 4424-5	#5-9183 #1&2-9293 4424	#5-83193 #1&2-9293 4424			
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L	mg/kg			
DRPH	5-6	50-60	500 ^a	<65 ^b <180 ^b	<60 ^b	<50 ^b	<50 ^b	<50 ^b	<50 ^b	<50 ^b	NA	<1,000 ^b	NA	<200	<50			
GRPH	0.1	1	100	<3 ^b <7 ^b	11 ^b	<1 ^b	<1 ^b	<1 ^b	<1 ^b	<1 ^b	NA	<100 ^b	<100 ^b	NA	<1			
RRPH (Approx.)	10-12	100-120	2,000 ^a	<130 <360	<120	<110	<110	<100	<100	<100	NA	<2,000	NA	<2,000	<100			
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 <0.31	7.51J	<0.10	<0.10	<0.10	0.28J	<0.10	<1 ^c	<1	<1	<1	<0.02			
Benzene	0.002	0.02	0.5	<0.03 <0.07	0.35	<0.02	<0.02	<0.02	<0.02	<0.02	<1 ^c	<1	<1	<1	<0.02			
Toluene	0.002	0.02		<0.03 <0.07	5.3	<0.02	<0.02	<0.02	<0.02	<0.02	<1 ^c	<1	<1	<1	<0.02 <0.03			
Ethylbenzene	0.002	0.02		<0.03 <0.07	0.26	<0.02	<0.02	<0.02	<0.02	<0.02	<2 ^c	<2	<2	<2	<0.04 <0.09			
Xylenes (Total)	0.004	0.04		<0.06 <0.1	1.6J	<0.04	<0.04	<0.04	0.28J	<0.04	NA	<1	<1	NA	<0.02			
HVOC 8010	0.002	0.02		<0.03 <0.07	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NA	<1	<1	NA	<0.02			
VOC 8260	0.020	0.020		<0.050J	NA	NA	NA	<0.020	NA	NA	<1	<1	<1	<1	<0.020			
SVOC 8270	0.200	<0.200	8,000	<3.80 <40.0	NA	NA	NA	<0.20- 2.16U	NA	NA	NA	NA	NA	NA	1.610			
TOC				84,200-297,000	NA	NA	NA	1,360	NA	NA	NA	NA	NA	NA	NA			

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

U Compound is not present above the concentration listed.

a The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

c BTEX determined by 8260 method analysis.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)			Matrix: Sediment Units: mg/kg												
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks	
					SD01	SD02	SD03	SD04	SD05	SD06	AB01	EB01	TB01	#1&2-82593 #5-8193 #3&4-8293	#6-82893 4397
Laboratory Sample ID Numbers					828	830	832	834	836	838		4395-2	1156/1158	776	
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/L	µg/L	µg/L	µg/L
DRPH	6-7	60-70	500 ^a	<65 ^b <180 ^b	270 ^b	500 ^b	480 ^b	<70 ^b	11,000 ^b	<60 ^b	NA	<1,000 ^b	NA	NA	<50
GRPH	0.2-0.3	2-3	100	<3 ^b <7 ^b	<2 ^b	1,200 ^b	NA	<3 ^b	114 ^b	<2 ^b	NA	<400 ^b	<50 ^b	NA	NA
RRPH (Approx.)	10-22	100-220	2,000 ^a	<130 <360	<100	<150	<220	<150	<140	<120	NA	<2,000	NA	<2,000	<100
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 <0.31	0.046J	4.00J	NA	<0.15	3.6J	<0.10					
Benzene	0.002-0.020	0.02-0.03	0.5	<0.03 <0.07	<0.02	<0.03	NA	<0.03	<0.03	<0.02	<1 ^c	<1	<1	<1	NA
Toluene	0.002-0.020	0.02-0.03		<0.03 <0.07	0.046J	<0.03	NA	<0.03	<0.03	<0.02	<1 ^c	<1	<1	<1	NA
Ethylbenzene	0.002-0.020	0.02-0.03		<0.03 <0.07	<0.02	1.4J	NA	<0.03	0.6J	<0.02	<1 ^c	<1	<1	<1	NA
Xylenes (Total)	0.004-0.040	0.04-0.06		<0.05 <0.1	<0.19	2.6J	NA	<0.06	3.3J	<0.04	<2 ^c	<2	<2	<2	NA
HVOC 8010	0.002-0.003	0.02-0.03		<0.03 <0.07	<0.02	<0.03	NA	<0.03	<0.03	<0.02	NA	<1	<1	NA	NA
PCBs	0.01-0.02	0.1-0.2	10	<0.1 <0.4J	<0.1	<0.1	<0.2J	<0.1J	<0.1	<0.1J	NA	<2	NA	NA	<0.1

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

a The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.

b DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

c BTEX determined by 8260 method analysis.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)		Matrix: Sediment Units: mg/kg		Environmental Samples		Field Blanks		Lab Blanks	
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	SD07 & SD08 (Replicates)	AB01	EB01	TB01	
Laboratory Sample ID Numbers					840 4397-8	4395-2	1156/1158 4424-4	776 4395-1	#5-9193 4424 4395
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L	mg/kg
DRPH	6-7	60-70	500 ^a	<65J ^b <180J ^b	300J ^b	NA	<1,000 ^b	NA	<50
GRPH	0.2-0.3	2-3	100	<3J ^b <7J ^b	790J ^b	NA	<400J ^b	<50J ^b	NA
RRPH (Approx.)	12	120	2,000 ^a	<130 <350	<120	NA	<2,000	NA	<100
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 <0.31	7.5J	8.3J			
Benzene	0.002-0.020	0.02-0.03	0.5	<0.03 <0.07	<0.02	<1 ^c	<1 ^c	<1	NA
Toluene	0.002-0.020	0.02-0.03		<0.03 <0.07	<0.02	<1 ^c	<1 ^c	<1	NA
Ethylbenzene	0.002-0.020	0.02-0.03		<0.03 <0.07	1J	<1 ^c	<1 ^c	<1	NA
Xylenes (Total)	0.004-0.040	0.04-0.06		<0.05 <0.1	6.5J	<2 ^c	<2 ^c	<2	NA
HYOC 8010	0.002-0.003	0.02-0.03		<0.03 <0.07	<0.02	NA	<1	<1	NA
SVOC 8270									
Naphthalene	0.200	2.3-2.5		<3.80 <40.0	1.87J	NA	NA	NA	<0.200
2-Methylnaphthalene	0.200	2.3-2.5		<3.80 <40.0	2.58	NA	NA	NA	<0.200
Pesticides	0.001-0.05	0.01-0.5		<0.01J <1.8J	<0.01J <0.5J	NA	<0.2J <25F	NA	<0.01

□

CT&E Data.

■

F&B Data.

NA

Not analyzed.

J

Result is an estimate.

R

Result has been rejected.

a

The action levels for DRPH and RRPH are based on conversations with ADEC; final action levels have not yet been determined.

b

DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

c

BTEX determined by 8260 method analysis.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (S503)				Matrix: Soil/Sediment Units: mg/kg												
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	Environmental Samples						Field Blanks			Lab Blanks		
					2S08	2S09	2S10	2S11 & 2S12 (Replicates)	2SD08	2SD10	AB01	2EB02	2TB03			
Laboratory Sample ID Numbers					4627-15	4627-16	4627-19	4627-20	4627-21		4627-14	4395-3	4627-23	4627-22	4627	4627
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	μg/L	μg/L	μg/L	μg/L	mg/kg
DRPH	4.00	4.00	500 ^a	<0.03 ^b <0.03 ^b	109 ^e	8.49 ^d	7.21 ^d	55.7 ^d	29.5 ^d	195 ^f	686 ^g	NA	NA	NA	NA	<4.00
GRPH	0.400	0.400-0.600	100	<3.0 ^b <7.0 ^f	0.799	3.19	<0.400	<0.600	3.30	<0.500	47.6	NA	<50	NA	<20	<0.400
BTEX (8020/8020 Mod.)			10 Total BTEX	<0.14 <0.31	NA	<0.125 ^c	<0.125 ^c	NA	0.413 ^c	<0.125	1.526					
Benzene	0.020	0.025-0.120	0.5	<0.03 <0.07	NA	<0.025 ^c	<0.025 ^c	NA	<0.025 ^c	<0.025	<0.120	<1 ^c	<1	<1 ^c	<1	<0.020
Toluene	0.020	0.025-0.120		<0.03 <0.07	NA	<0.025 ^c	<0.025 ^c	NA	<0.025 ^c	<0.025	<0.120	<1 ^c	<1	<1 ^c	<1	<0.020
Ethylbenzene	0.020	0.025-0.120		<0.03 <0.07	NA	<0.025 ^c	<0.025 ^c	NA	0.038 ^c	<0.025	0.330	<1 ^c	<1	<1 ^c	<1	<0.020
Xylenes (Total)	0.040	0.050-0.240		<0.05 <0.1	NA	<0.050 ^c	<0.050 ^c	NA	0.375 ^c	<0.050	1.196	<2 ^c	<2	<2 ^c	<2	<0.040
VOC 8260	0.020	0.020-0.025		<0.050J	NA	<0.025	<0.020	NA	<0.025	NA	NA	NA	NA	NA	NA	<0.020

CT&E Data.

F&B Data.

Not analyzed.

Result is an estimate.

The action level for DRPH is based on conversations with ADEC; a final action level has not yet been determined.

DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

BTEX determined by 8260 method analysis.

The laboratory reported that the EPH pattern in this sample was not consistent with a middle distillate fuel.

The laboratory reported that 88.7 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

The laboratory reported that 54.9 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

The laboratory reported that 60.5 mg/kg of the EPH pattern in this sample was not consistent with a middle distillate fuel.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

METALS ANALYSES												
Installation: Point Barrow Site: Air Terminal Area (SS03)		Matrix: Soil/Sediment Units: mg/kg										
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples				Field Blank			Lab Blanks
					S04-4	SD07 & SD08 (Replicates)					EB01	
Laboratory Sample ID Numbers					4424-1	4397-8	4397-9				4424-4	4397 4424
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg				µg/L	µg/L
Aluminum	0.35	2-800		1,500-23,000	<800	1,900	800				<100	<100
Antimony	N/A	5.5-65		<7.8-<230	<5.5	<65	<58				<100	<100
Arsenic	0.11	55-65		<4.9-<7.0	<55	<65	9.7				<100	<100
Barium	0.024	1		27-390	70	67	44				<50	<50
Beryllium	N/A	2.7-3.2		<2.6-6.4	<2.7	<3.2	<2.9				<50	<50
Cadmium	0.33	2.7-3.2		<3.0-<27	<2.7	<3.2	<2.9				<50	<50
Calcium	0.69	4		360-59,000	680J	2,200	760				220	<200
Chromium	0.066	1-2.7		<4.3-47	<2.7	25	6.2				<50	<50
Cobalt	N/A	5.5-6.5		<5.1-12	<5.5	<6.5	<5.8				<50	<100
Copper	0.045	1-2.9		<2.7-45	2.8	4.3	<2.9				<50	<50
Iron	0.50	2		5,400-35,000	5,600	9,000	4,700				<100	<100
Lead	0.13	2-5.5		<5.1-22	<5.5	140	47				<100	<100
Magnesium	0.96	4		360-7,400	400J	1,500	370				<200	<200
Manganese	0.025	1		25-290	25	30	19				<50	<50
Molybdenum	N/A	2.7-3.2		<2.5-<11	<2.7	<3.2	<2.9				<50	<50
Nickel	0.11	1-2.9		4.2-46	3.0	5.4	<2.9				<50	<50
Potassium	23	100		<300-2,200	330	610	330				<5,000	<5,000

☐ CT&E Data.
☐ N/A Not available
☐ J Result is an estimate.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)			Matrix: Soil/Sediment Units: mg/kg		METALS ANALYSES							
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples				Field Blank		Lab Blanks	
					S04-4	SD07 & SD08 (Replicates)				EB01		
Laboratory Sample ID Numbers					4424-1	4397-8	4397-9			4424-4		4397 4424
ANALYSES	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			µg/L		µg/L
Selenium	1.2	5.5-65		<7.8-<170	<5.5	<65	<58			<100		<100
Silver	0.53	2.7-32		<3-<110	<2.7J	<32J	<29			<50		<50
Sodium	0.55	5		<160-680	86	200	120			<250		<250
Thallium	0.011	0.27-0.32		<0.2-<0.82	<0.27	<0.32	<0.29			<5		<5
Vanadium	0.036	1		6.3-59	8.5	13	6.7			<50		<50
Zinc	0.16	1		9.2-95	9.2	56	23			<50		<50

☐ CT&E Data.
J Result is an estimate.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)				Matrix: Surface Water Units: µg/L				Environmental Samples							Field Blanks			Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkqd. Levels	SW01	SW02	SW03	SW04 & SW08 (Duplicates)	SW05	SW06	SW07	AB01	EB01	TB01				
Laboratory Sample ID Numbers					794/843	798/844	800/845	800/846 4396-1	814/850 4396-3	810/848	812/846 4396-2	4395-2	1156/1158 4424-4	776 4395-1	#5-82863 4424/4395/4396			
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L			
DRPH	100	1,000	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	<1,000 ^b	NA	<1,000 ^b	NA	<200			
GRPH	5	50	<50 ^b	<50 ^b	<50 ^b	200 ^b	135 ^b	<50 ^b	1,125 ^b	<50 ^b	2,000 ^{a,b}	NA	<100 ^b	<50 ^b	NA			
RRPH (Approx.)	200	2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	NA	<2,000	NA	<2,000			
BTEX (8020/8020 Mod.)																		
Benzene	0.1	1	5	<1	<1	<1	<1	<1	89	<1	22R	<1 ^c	<1	<1	<1			
Toluene	0.1	1	1,000	<1	<1	<1	10	<1	<1	<1	110R	<1 ^c	<1	<1	<1			
Ethylbenzene	0.1	1	700	<1	<1	<1	5	<1	21	<1	86R	<1 ^c	<1	<1	<1			
Xylenes (Total)	0.2	2	10,000	<2	<2	11	11	<2	260	<2	120R	<2 ^c	<2	<2	<2			
HVOC 8010	0.1	1		<1	<1	<1	<1	<1	<1	<1	<1R	NA	<1	<1	NA			
VOC 8260																		
Benzene	1	1	5	<1	NA	NA	NA	<1	NA	NA	16	<1	<1	<1	<1			
1,2-Dichloroethane	1	1	5	1.2	NA	NA	NA	<1	1.6J	NA	<1	<1	<1	<1	<1			
Ethylbenzene	1	1	700	<1	NA	NA	NA	<1	NA	NA	4.8	<1	<1	<1	<1			
Naphthalene	1	1		<1	NA	NA	NA	1.1J	<1	NA	4.2	<1	<1	<1	<1			
Toluene	1	1	1,000	<1	NA	NA	NA	<1	NA	NA	74	<1	<1	<1	<1			
1,2,4- Trimethylbenzene	1	1		<1	NA	NA	NA	2.7	2.4	NA	8.9	<1	<1	<1	<1			

□ CT&E Data.

■ F&B Data.

NA Not analyzed.

J Result is an estimate.

R Total petroleum hydrocarbons in these water samples exceed the 15 µg/L stated for fresh water in ADEC's Water Quality Criteria 18AAC70 (ADEC 1989).

a DRPH and GRPH concentrations reported for these samples are equivalent to diesel and gasoline range organics (DRO and GRO) as defined by ADEC.

b BTEX determined by 8260 method analysis.

c

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)				Matrix: Surface Water Units: µg/L		Environmental Samples										Field Blanks			Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Levels	SW01	SW02	SW03	SW04 & SW08 (Duplicates)	SW05	SW06	SW07	AB01	EB01	TB01					
Laboratory Sample ID Numbers					794/843	798/844	800/845	800/846 4396-1	814/850 4396-3	806/847	810/848	812/846 4396-2	4395-2	1156/1158 4424-4	776 4395-1	#5-82893 4424/4395/4396			
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L			
1,3,5- Trimethylbenzene	1	1		<1	NA	NA	NA	3.4	3.0	NA	NA	NA	<1	<1	<1	<1			
Xylenes (Total)	2	2	10,000	<1	NA	NA	NA	6.6	6.3	NA	NA	NA	<2	<2	<2	<2			
SVOC 8270	10	11		<10-<25	NA	NA	NA	<11	<11	NA	NA	NA	NA	NA	NA	<10			
PCBs	0.2	2	0.5	<2	<2	<2	<2	<2	<2	<2	<2	NA	<2	NA	NA	NA			
TOC	5,000	5,000		16,700-22,500	NA	NA	NA	18,000	17,200	NA	NA	NA	NA	NA	NA	<5,000			
TSS	100	200		5,000-6,000	NA	NA	NA	12,000	12,000	NA	NA	NA	NA	NA	NA	<200			
TDS	10,000	10,000		166,000J-213,000	NA	NA	NA	698,000	677,000	NA	NA	NA	NA	NA	NA	<10,000			

☐ CT&E Data.
☒ F&B Data.
☒ Not analyzed.
 Result is an estimate.

☐ NA
 J

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)			Matrix: Surface Water Units: µg/L		METALS ANALYSES: TOTAL (DISSOLVED)							
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples					Field Blank		Lab Blanks
					SW04 & SW08 (Duplicates)	SW07					EB01	
Laboratory Sample ID Numbers					4396-1	4396-3	4396-2					4424 4396
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L					µg/L
Aluminum	17.4	100		<100-350 (<100-340)	<100 (<100)	<100 (<100)	<100 (<100)				<100	<100
Antimony	N/A	100	6	<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)				<100	<100
Arsenic	5.3	100	50	<50-93 (<50-91)	<50 (<50)	<50 (<50)	120 (79)				<100	<100
Barium	1.2	50	2,000	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50	<50
Beryllium	N/A	50	4	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50	<50
Cadmium	1.7	50	5	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50	<50
Calcium	34.5	200		4,500-88,000 (4,100-86,000)	38,000 (38,000)	35,000 (36,000)	41,000 (38,000)				220	<200
Chromium	3.29	50	100	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50	<50
Cobalt	N/A	100		<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)				<50	<50
Copper	2.3	50	1,300	<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)				<50	<50
Iron	25	100		180-2,800 (<100-1,600)	3,100 (370)	2,800 (360)	6,000 (170)				<100	<100

☐ CT&E Data.
N/A Not available.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)				Matrix: Surface Water Units: µg/L		METALS ANALYSES: TOTAL (DISSOLVED)										Field Blank		Lab Blanks
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples													
					SW04 & SW08 (Duplicates)		SW07											
Laboratory Sample ID Numbers						4396-1	4396-3	4396-2									4424 4396	
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L									µg/L	µg/L
Lead	6.6	100	15		<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)									<100	<100
Magnesium	47.8	200			2,900-53,000 (2,600-54,000)	35,000 (34,000)	35,000 (34,000)	42,000 (40,000)									<200	<200
Manganese	1.24	50			<50-510 (<50-120)	160 (140)	140 (130)	160 (98)									<50	<50
Molybdenum	N/A	50			<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)									<50	<50
Nickel	5.5	50	100		<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)									<50	<50
Potassium	1,154	5,000			<5,000 (<5,000)	5,900 (5,500)	10,000 (11,000)	7,300 (6,700)									<5,000	<5,000
Selenium	62.4	100	50		<100 (<100)	<100 (<100)	<100 (<100)	<100 (<100)									<100	<100
Silver	2.6	50	50		<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)									<50	<50
Sodium	27.7	250			8,400-410,000 (8,200-450,000)	100,000 (97,000)	160,000 (160,000)	130,000 (120,000)									<250	<250
Thallium	0.57	5	2		<5 (<5)	<5 (<5)	<5 (<5)	<5 (<5)									<5	<5
Vanadium	1.8	50			<50 (<50)	<50 (<50)	<50 (<50)	<50 (<50)									<50	<50

☐ CT&E Data.
☐ N/A Not available.

TABLE G-5. AIR TERMINAL AREA ANALYTICAL DATA SUMMARY (CONTINUED)

Installation: Point Barrow Site: Air Terminal Area (SS03)				Matrix: Surface Water Units: µg/L		METALS ANALYSES: TOTAL (DISSOLVED)							Lab Blanks	
Parameters	Detect. Limits	Quant. Limits	Action Levels	Bkgd. Range from 7 DEW Line Installations	Environmental Samples							Field Blank		
					SW04 & SW08 (Duplicates)	SW07							EB01	
Laboratory Sample ID Numbers					4396-1	4396-3	4396-2						4424-4	4424 4396
ANALYSES	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L						µg/L	µg/L
Zinc	8.2	50		<50-160 (<50)	<50 (<50)	<50 (<50)	<50 (<50)						<50	<50

☐ CT&E Data.
N/A Not available.